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PROCEEDINGS OF THE THIRTEENTH INDIAN SCIENCE CONGRESS.

OFFICERS OF THE THIRTEENTH CONGRESS.

PATRON :

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3. Prof. B. Sahni, M.A. (Cantab) D.Sc. (Lond.), F.G.S., (Elected by the General Committee.)
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4*b*. Dr. S. L. Hora, D.Sc., (appointed 27-7-1925.) } Treasurer.
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7. Prof. S. P. Agharkar, M.A., Ph.D., F.L.S. } General Secretaries.

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(b) *Past Presidents resident in India.*

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9. Sir R. N. Mukherji, K.C.I.E , K.C.V.O.
10. Sir M. Vishweshwarayya, K.C.I.E., M. Inst. C.E., D.Sc.

(c) *Members Elected by the General Committee.*

11. Prof. S. L. Ajrekar, M.A.
12. Prof. D. M. Bose, M.A., B.Sc., Ph.D.
13. Mr. H. C. Das-Gupta, M.A., F.G.S.
14. Prof. G. Mathai, M.A , F.Z.S.
15. Dr. E. R. Watson, M.A , D.Sc.

The Thirteenth Meeting of the Indian Science Congress was held in Bombay from January 4th to the 7th, 1926. After a speech of welcome from H. E. Sir Leslie Wilson, Governor of Bombay, the President, Mr. A. Howard, C.I.E., M.A., delivered his address.

The Sectional Presidential Address were delivered as follows :—

Tuesday, January, 5th, 10 A.M. Medical and Veterinary Research; 11 A.M., Psychology; 12 noon; Anthropology.

Wednesday, January, 6th, 10 A.M. Agriculture; 11 A.M. Botany; 12 noon; Zoology.

Thursday, January, 7th, 10 A.M. Mathematics and Physics; 11 A.M. Chemistry; 12 noon, Geology.

The following functions were arranged in connection with the Congress :—

January 4th, "At Home" by the Principal and Members of Staff, Royal Institute of Science, Bombay.

January 5th, Visits to :—(1) Central Cotton Research Laboratory; (2) V. J. Technical Institute; (3) G.I.P. Ry. Workshops, Parel; (4) Lightfoot Refrigeration Company; (5) Hospitals and Maternity Homes (for medical men only); (6) Dharamsi Morarji Chemical Works at Ambarnath

January 6th, Visits to :—(1) His Majesty's Mint; (2) Bombay Port Trust; (3) Colaba observatory.

Tea Party given by Mr. Byramjee R. B. Jeejeebhoy at Malabar Castle.

January 7th, Visit to Bombay Development Department. Chancellor, Vice-Chancellor and Fellows of the Bombay University "At Home," Senate Hall.

January 8th, Visit to Haffkine Institute, Parel; Visit to Govardhandas Sunderdas Medical College, Parel; Tea Party at Haffkine Institute.

January 9th, Visit to :—(1) Elephanta caves; (2) Alibag observatory; (3) Khopoli (Hydro-electric works).

Public lectures were delivered as follows :—

January 5th, on "Droughts and Famines" by Dr. H. H. Mann.

January 6th, on "Life at High Altitudes in Western Tibet" by Prof. S. R. Kushyap.

January 7th, On "Modern applications of X-rays" by Prof. H. Parameswaran.

Joint meetings of various sections were held as follows :—

January 5th. Sections of Agriculture, Mathematics and Physics, Chemistry, Zoology and Botany.
Subject :—Recent Scientific Work directed to the Improvement of Cotton-growing.
January 6th. Sections of Mathematics and Physics and Chemistry.
Subject :—Structure of the Atom and Quantum theory.

The Executive Committee met on January 6th.

The General Committee met on January 7th.

A Souvenir volume "Bombay, Past and Present" was issued to members.

Presidential Address.

Congress President:—ALBERT HOWARD, C.I.E., M.A.

AGRICULTURE AND SCIENCE.

The application of science to agriculture is a comparatively modern development. Since 1834, when Boussingault laid the foundations of agricultural chemistry, an increased and increasing amount of attention has been devoted to agriculture by men of science. I propose briefly to re-capitulate some of the more important advances which have resulted from this impact of organized knowledge on the most ancient of the arts and then to deal in greater detail with some of the agricultural problems of to-day in the solution of which science is certain to play an important part. In reviewing the development of agricultural science, two things must be kept in view—the influence of science on practice and, what is perhaps more interesting, the lessons which agriculture has taught and is still teaching the scientific investigator. I hope to show that the great benefits that have flowed from the application of science to practice are not always on the side of agriculture but that scientific method itself has sometimes profited from the association. Further, the man of science has had to realize that progress is possible without the aid of science and that some of the greatest developments in agriculture, even at the present day, have been brought about by empirical means.

Examples of notable advances in agriculture which have taken place without the aid of science are to be found all over the world. In the Orient, perhaps the most remarkable is the cultivation of rice which has been developed by the people in the deltas of the great rivers to a high degree of perfection and carried up the slopes of valleys by means of a system of irrigated terraces. The care and skill which have enabled the cultivator to grow a semi-aquatic crop like rice on the steep hillsides of India and Ceylon cannot fail to command our attention and respect. In this development, science has played no part and even now has not completed the preliminary analysis of the factors involved in the growth of the chief cereal of the tropics. We can only guess at the sources of the nitrogen made use of by the rice plant. Again in Gujerat in this Presidency, an indigenous system of agriculture has been evolved to overcome a most difficult set of soil and moisture conditions. In order that the tilth may be maintained and the moisture conserved speed is essential in managing these soils. To get over the fields quickly, the crops are grown in straight lines; simple but effective implements have been designed for sowing and inter-culture and a fast and powerful breed of oxen has been developed. The adaptation of means to end is remarkable and great natural obstacles have been overcome by the peasantry unaided. In the Occident, equally striking advances have been made by empirical means. Subsoil drainage, the modern systems of tillage, the great progress which has been made in the breeding of live stock, the Norfolk four-course system of rotation—which followed the introduction of the turnip crop into Great Britain in 1730—are all improvements which owe nothing to the scientific investigator.

The pioneers of agricultural science were chemists A French chemist laid the foundation stone in 1834. Liebig's classical monograph on agricultural chemistry appeared in 1840 which instantly attracted the attention of agriculturists who, for the first time, were made acquainted with the help they were likely to obtain from the application of chemistry to the tillage of the soil. Three years later—in 1843—the Rothamstead Experiment Station was founded by Lawes and the great era of agricultural chemistry began which continued till the end of the last century. During this period agricultural science was a branch of chemistry. As long as the Liebig tradition endured, the analyses of soils and manures were regarded almost with veneration by the practical man and great hopes were entertained that something approaching a royal road in the development of agriculture had been discovered. This phase lasted nearly fifty years during which the use of artificial manures became firmly welded into the agricultural practice of the West. Experience of the new science, however, gradually showed that improvements in crop-production could not always be achieved by applying the principles laid down by Liebig. The deficiencies in the soil, suggested by chemical analysis, were not always made up by the addition of the appropriate artificial manure. The feeling slowly developed that the problems of crop-production could not be dealt with adequately by chemistry alone. The physical texture of the soil was found to be as important as its chemical composition. The pioneering work of Hilgard and King in America led to the development of a new branch of the subject—soil physics—the exploration of which is still in progress. Pasteur's work on fermentation and allied subjects discovered a new world and laid the foundation of the modern work on micro-organisms and disease. The soil was soon found to be inhabited by bacteria and other forms of life and a new branch of agricultural science—soil bacteriology—arose. The organisms concerned in the nitrification of organic matter in the soil were discovered by Winogradsky and the conditions necessary for their activity were determined. Hellriegel and Wilfarth worked out the rôle of the organisms which produce the nodules on the roots of leguminous plants and in 1888 furnished a scientific explanation of the value of these crops in enriching the soil. The Liebig conception of soil fertility was thus gradually enlarged, and it became clear that the problem of increasing the produce of the soil did not lie within the domain of any one science but embraced at least three—chemistry, physics and bacteriology. The great value of this broadening of the basis of agricultural science was to afford an explanation of practices which had been arrived at on the basis of experience and to add a number of important principles to the subject. It was not till the beginning of the present century that investigators began to pay attention to what is after all the chief agent in crop-production, the plant itself. The re-discovery of Mendel's law by Correns, the conception of the unit species which followed the work of Johannsen and the recognition of its importance in improvement by selection have led directly to the modern botanical studies of cultivated crops. These investigations are constantly broadening and now embrace the root-system, and its relation to the soil type as well as resistance to disease. It is an arresting fact that the development of modern plant-breeding came about indirectly and did not arise in the most logical manner, namely as an outgrowth of systematic botany and the intensive study of the Linnean species. Had the principles of systematic botany been rigorously applied to the various units which make up the Linnean species and had anybody collected the numerous forms of almost any wild plant and grown them side by side from single plants, the principles underlying improvement by selection would have been apparent and a sure foundation for modern plant-breeding would have been laid.

The practical results which have followed the application of botanical science to agriculture during the last quarter of a century are very considerable. In wheat for example, the labours of Saunders in Canada culminated in the production of Marquis—a variety obtained by crossing Red Fife with an early Indian wheat (Hard Red Calcutta). Marquis closely resembles Red Fife in appearance in the field and in the high quality of its grain. It differs from the parent in earliness and in having a shorter straw. Marquis is the most successful hybrid yet produced. Over 20,000,000 acres of this variety are grown in Canada and the neighbouring States of the Union. In Australia, the new wheats raised by Farrer are widely cultivated. In England, Biffen's new hybrid Yoeman has definitely established itself in the wheat-growing areas of the country. In India, the types produced by the Pusa Research Institute already cover more than 2,000,000 acres. The total area of the new varieties of wheat produced during the present century must be little short of twenty-five million acres. At a moderate estimate, the increased wealth produced by the application of modern methods of plant-breeding to this crop must be at least 20,000,000 sterling a year. If this annual dividend is compared with the capital invested, the return is many times greater than that yielded by the most successful industrial enterprise. The methods which have proved successful in wheat are now being applied in India to crops like cotton, rice, jute and sugar-cane and important results have already been obtained. During the next generation, the replacement of inferior varieties by more efficient and higher yielding types is certain to make rapid progress and in a few years the total annual addition to the wealth of the world will run into hundreds of millions sterling. Important as is the total annual increment which follows the general adoption of a successful variety, nevertheless the gain per acre is small. Even in the most favourable circumstances it is not likely to exceed twenty rupees an acre. As in the case of Marquis and the Pusa wheats, the advantage is partly due to earliness and partly to the improved quality of the grain. The new varieties are more efficient and make better use of the food materials provided by the soil than the old. Their cultivation secures a more certain crop and also one of increased market value. It by no means follows that the new kinds require more from the soil and that their cultivation will be followed by a loss of permanent fertility. The improvement is closely similar to that obtained by replacing an inefficient machine by one which is better designed to do the same work.

Even when the cultivated area of the world has been provided with better varieties, only the first instalment of the practical results, which flow from the modern studies of crops, will have been secured. The great problem of the agriculture of the near future is the intensive cultivation of improved varieties by which the present production can be vastly increased in quantity as well as improved in quality.

A survey of the development of agricultural science during the last ninety years reveals the important fact that until quite recently the approach has almost always been by means of one science. The researches fall into classes, each class coinciding with the limits of some well-defined subject like chemistry, physics, bacteriology, entomology or botany. Not only can the researches be easily grouped but the organization of agricultural workers closely follows the artificial sub-division of science which has grown up in the colleges and Universities as a result of the exigencies of teaching and examinations. Further, the history of the application of each science to agriculture follows much the same course. First of all there is a period of optimism after the publication of the early results. This is slowly followed by a more chastened outlook as it becomes apparent that the new science is not quite adequate by itself to deal with the many-sided problems of practice. Finally, direction is gradually lost and the effort not infrequently loses itself in detail.

I propose at this stage to examine two of the chief problems which now confront the agricultural investigator in India and I hope to show that these problems do not fall within the limits of any single branch of science. It naturally follows therefore that the conventional method of attack cannot hope to be completely successful.

Irrigation and Agriculture.

The discovery of the right use of irrigation water is one of the chief tasks now before the Agricultural Department in India. As every one knows, everything goes well in this country if the rains are timely, well distributed and ample in volume. Trade flourishes, there is contentment in the villages and in due course the officials connected with finance have the pleasant duty of announcing either the remission of taxation or suggesting useful schemes on which the surplus revenue can be spent. All this follows because water is one of the limiting factors in the growth of crops. Hence the development of canal irrigation from rivers to supplement the rainfall. At first sight, all that seems needed is that the engineers should dam a river and distribute the impounded water over the country-side according to a time-table. The factor—shortage of water—which limits production can in this way be removed. For the canal to pay its way and to bring in the greatest revenue, the water has to be distributed so that the most expensive crops like cotton and sugar-cane can be grown. This involves fairly frequent waterings so that there is no cessation of growth between sowing and harvest. Hence the institution of perennial irrigation and the concentration of the cultivated area commanded so that the highest duty of the water and the maximum revenue can be obtained. When, however, we carefully compare the growth of the same crop under canal irrigation and under normal rainfall, interesting differences can at once be detected. The irrigated crop as a rule does not appear to be quite at home. Ripening is frequently delayed and the quality of the produce is apt to be irregular and inferior. Further, the standard of cultivation under a canal tends to deteriorate. After a few years, the producing power of the soil falls off; patches of alkali land often appear and grow in size and there is a tendency for the villages to become malarious. Compared with the best well-irrigated regions or with localities where the crops are grown on the natural rainfall, the well-being of both plants and animals on the perennial canal leaves a good deal to be desired. Canal irrigation in the hands of the cultivator seems to put a brake on the wheel of life. In some places, as for example on the Nira canal in Bombay, the wheel of life is brought to a standstill altogether by the land becoming a wilderness of alkali on which nothing can grow. Here the canal has produced dead soil. How is it that things have gone wrong and why is there this difference between experience and theory ? The answer is to be found in the fact that rainfall and canal irrigation are different things from the point of view of the plant. It is true that rainfall and irrigation have one factor in common, namely, the provision of water. In almost every other respect, however, they are quite different. Rain is a saturated solution of oxygen in water and usually reaches the soil so slowly and at such long intervals that it does not destroy texture to anything like the same extent as canal water does. Moreover, it supplies the soil with oxygen in a highly effective form. Canal water is much poorer in oxygen, it destroys the tilth and the total period of its application to any particular crop is only a matter of an hour or two. Further, when the surplus irrigation water cannot flow away underground there is a gradual rise of the subsoil water-level which may reach almost to the surface. Small as these differences at first sight appear, nevertheless they are sufficiently important in the course of a few years to bring about a marked fall in the fertility of the soil.

Why there should be such a tendency towards intense malaria, when dry crops are grown under canal irrigation, is a matter which has not yet been satisfactorily explained. Is it merely due to the accumulation of surface water providing breeding grounds for mosquitoes or is a part of the answer to be found in the lowered resistance of the people ? Have the wheat and other food-grains, produced under canal irrigation, the same food-value as those grown under natural rainfall or with the help of wells ? Do the nutritive and vitamin values of food-grains vary with the conditions of their growth ? Science cannot at the moment answer these questions but these are indications that the food value of the same cereal depends on the conditions under which it is grown. This matter urgently calls for careful investigation. McCarrison[1], working in Madras, was on the eve of throwing light on these questions when his researches were brought to an end by retrenchment. During the course of an exhaustive enquiry into the food value of the rices in common use in India, this investigator found the various kinds differed considerably in nutritive value. No reason for this could be detected in their chemical composition and it appeared that the differences might be due in part to their vitamin content. As rice was not available at the moment, the matter was put to the test of experiment using the same kind of millet from the permanent experimental plots at the Coimbatore Experiment Station. These plots have been in existence about fifteen years and have been manured in various ways. In the feeding experiments on animals, the millet grown on soil manured with cattle manure was more nutritious and contained more vitamins than that grown on soil manured with artificial manure; that grown on exhausted soil being the worst of all in these respects. McCarrison writes "I was in the middle of this work when my researches came to an untimely end owing to financial retrenchments in India so I was not able to repeat the experiment nor to extend them to other grains." That there does exist a definite relationship between the incidence of malaria and the way crops are grown is suggested by the observations of Bentley in Bengal. In this Province, the prevalance of malaria and the inundation of the rice areas are closely connected. In such tracts as Eastern Bengal, which are subject to annual inundation, the rice crops are excellent, there are practically no waste lands, the population is large and malaria exists to so slight an extent as to be almost negligible. In parts of Central and Western Bengal, however, quite a different state of things exists. The greater part of the Districts of Nadia, Murshidabad, Hooghly and Burdwan have been deprived of the natural inundations to which they were once subject by the construction of river-embankments. In the old days, 60 or 70 years ago, these embankments were kept in such bad repair that they did not prevent flooding of the country and their harmful effect was not apparent. When they were made really efficient barriers to the inundation, the protected areas began to suffer in several ways. The fertility of the soil diminished, the area of waste land increased, population declined and with it malaria increased to an appalling extent. Where rice is grown to perfection there is little malaria; where the crop is cut off from the necessary inundation, malaria is rife. In all probability the same rule applies to dry crops like wheat. It may easily prove to be that the intense malaria which often follows in the wake of the canal in North-West India is not altogether due to the mosquito but is a consequence of the lowering of the quality of the food-grains grown under canal irrigation. The subject is one which calls for early investigation and it is hoped that McCarrison's interesting work on the influence of soil conditions on the nutritive value of the chief food grains of India will be continued and that the investigation will be widened to embrace the effect of the quality of wheat on resistance to diseases like malaria.

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[1] *Jour. Roy. Soc. of Arts,* LXXIII, 1925, p. 152.

Of equal importance to the increase in malaria is the deleterious effect of canal irrigation on the fertility of the soil. When the desert is conquered by the canal, all goes well at first and large crops are raised with a comparatively small volume of irrigation water. As time goes on, however, the soil particles fall into a condition of closer and closer packing and as the natural texture of the desert soil is lost, more and more water is needed by the cultivator to raise his crops. Defective soil-aeration soon becomes a limiting factor in growth. The yields begin to fall off with surprising rapidity as is shown by the results with wheat at Mirpurkhas in Sind. The next stage is the appearance of alkali patches which slowly increase in size till the land goes out of cultivation. The rate of transformation of potentially fertile desert soil into useless alkali land is, other things being equal, inversely proportional to the size of the soil particles. Open, porous soils are not affected to any great extent by perennial irrigation. Close, heavy soils, containing a high proportion of fine particles, are, however, particularly prone to develop the alkali condition.

Very little progress in the prevention and cure of alkali soils has been made up to the present in India. All attempts to reclaim these soils on the large scale have proved to be impossible on economic grounds. Further, almost nothing is known of the causes which produce the alkali phase. The conventional view that alkali soils are the natural consequence of a light rainfall, insufficient to wash out of the land the salts which always form in it by the progressive weathering of the rock powder of which all soils largely consist, is persistently re-iterated. Hence alkali lands are considered to be a natural feature of arid tracts like the Punjab and Sind where the rainfall is very small. These ideas on the origin and occurrence of alkali land, however, do not correspond with all the facts. Alkali soils are common in the sub-montane tracts of North Bihar where the rainfall is between 50 and 60 inches. Arid conditions, therefore, are not essential for the production of these salts ; heavy rainfall does not always remove them. What does appear to be a necessary condition is defective soil-aeration. Whenever the air supply is cut off by the constant surface irrigation of stiff soils or by other causes, alkali salts sooner or latter appear. If these barren areas are examined, they are frequently found to contain the bluish-green markings which are associated with the activities of anaerobic bacteria. These organisms appear to bring about a reductive phase in the soil which involves the formation of substances like sulphuretted hydrogen and the metallic sulphides. When circumstances alter and oxidation again takes place, the salts of alkali land—the sulphate, chloride and carbonate of sodium—are produced. That the origin of alkali is due to defective soil aeration which slowly establishes an anaerobic soil flora is supported by a large number of facts and observations. In the alkali zone of North Bihar, wells have to be left open to the air otherwise the water is contaminated by sulphuretted hydrogen thereby indicating a well marked reductive phase in the deep soil layers. In a sub-soil drainage experiment in the Nira valley, Mann and Tambane found that the salt water which ran out of these drains soon smelt strongly of sulphuretted hydrogen and a white deposit of sulphur was found at the mouth of each drain proving how strong was the reducing action in this soil. Here the reductive phase in alkali formation was actually demonstrated. After drainage and aeration were established, the conditions necessary for alkali production were removed and the original texture and fertility of the soil were restored. These and many other examples point to the supreme importance of further investigation of the origin of alkali lands in India and the discovery of the conditions which are necessary for their formation. Once this is known, it will be possible to shape our irrigation policy so that the water can be made use of without lowering the permanent fertility of the country-side. Such an investigation is particularly necessary in India at the present time in view of the pending development of canal irrigation in Sind. A barrage is being thrown across the Indus below Sukkur, and a system of intensive perennial irrigation was at one time contemplated for the growth of crops like cotton and wheat. The soil, however, is much closer in texture than that of the Canal Colonies of the Punjab, there are no deep sand layers to assist percolation, and the level of the subsoil water is comparatively near the surface. There is therefore every reason to fear that the soil conditions of the area commanded by the Sukkur barrage are such that intensive perennial irrigation will produce a vast expanse of dead alkali land.[1] Such a disaster can probably be averted by altering the method of distribution so as to give the land as much rest as possible from irrigation. A new method of irrigation must be evolved (intermediate between the modern perennial system and the old basin method) by which irrigation and soil-aeration can be combined. This is one of the results which is expected from the new Irrigation Experiment Station in Sind which has just been sanctioned by the Government of Bombay.

The effective addition of water to make up for a deficient rainfall is therefore not a simple matter. It lies far outside the province of the engineer and embraces not only the health and well-being of the people but also the main facts of rural economy as well as the problem of the maintenance of the fertility of the soil. Such questions do not fall within the limits of any one science and it is obvious that their solution can only be accomplished by investigators of great experience, capable of bringing several sciences simultaneously to bear on these problems.

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[1] In his *Irrigation and Drainage* (London, 1900) King concludes an interesting discussion of this question in the following words, which deserve the fullest consideration on the part of the irrigation authorities in India. "It is a noteworthy fact that the excessive development of alkalies in India as well as in Egypt and California, are the result ot irrigation practices modern in their origin and modes and instituted by people lacking in the traditions of the ancient irrigators who had worked these same lands thousands of years before. The alkali lands of to-day, in their intense form, are of modern origin, due to practices which are evidently inadmissible and which in all probability were known to be so by the people whom our modern civilisation has supplanted."

Diseases of Plants.

When we turn to the biological aspects of agricultural work, the great complexity of the subject and the interaction of the fields, covered by the separate sciences, become most apparent. In following the growth of a crop from the seed, many branches of natural science are involved. The food materials provided by the soil are prepared by bacteria; drawn into the plant and transported by physical means; elaborated into useful products by chemical processes while the resulting growth produces organs which are studied by the botanist. Biological questions are therefore a complex of all sciences. Many of the problems of agriculture, particularly in the tropics, centre round the growth of the plant. How closely this complexity influences the successful solution of agricultural problems is seen when we consider the diseases of plants.

In recent years perhaps more attention has been paid to the diseases of crops than to any other branch of agriculture. One reason for this would appear to be that the detailed examination of the insects and fungi concerned in plant diseases can easily be carried out by specialists in an ordinary laboratory and do not involve much equipment. In spite of the vast literature on diseases which has accumulated as a result of the researches of the last thirty years, agricultural practice has been remarkably little influenced. This result at first sight appears surprising. It seems so obviously the right thing to ascertain the nature of the pest and to attack its weakest and most vulnerable phase. It is, however, now being recognized that direct attack by assault and battery is nearly always useless and economic entomology and mycology are becoming transformed into plant pathology, thus bringing these subjects into line with the new developments in medical thought.

The moment we begin to study the diseases of plants from a broad standpoint it becomes apparent that a great deal besides the life-history of the fungus or of the insect is involved. The variety of the particular crop is perhaps more important than the parasite and the effect of the environment on both is often very considerable. That the insect or the fungus is only one factor in the problem is seen when large numbers of unit species, belonging to several varieties of a crop like wheat, are grown side by side under similar conditions for a number of years. The resistance of the unit species to the various rust fungi differs widely. Some unit species are practically immune, the rest are attacked to varying degrees. Although there is always plenty of infecting material, the immune types escape.

It has not yet been possible directly to discover on what the immunity of certain species, varieties and unit species depends but some light is thrown on the subject by another set of observations. It has frequently been noticed that improper methods of agriculture are almost certain to be followed by attacks of disease even in cases when the variety possesses a fair degree of disease resistance. Moreover, it has been found possible to induce experimentally attacks of disease by altering the conditions of growth. Thus einkorn (*Triticum monococcum* L.), the most rust resistant species of wheat known, became covered with pustules of black rust (*Puccinia graminis* Pers.) when grown during the hot season at Pusa. Further by altering the time of irrigation at Quetta, peach trees could be covered with green-fly while neighbouring trees of the same variety, watered normally, remained free from this pest. Researches in other parts of the world tend to show that this and allied results follow alterations in the chemical composition of the cell-sap brought about by changes in the general metabolism induced by the altered methods of cultivation. The pest will only become acute if certain substances are present in the cell in quantity—a close parallel with the recent work on cancer in Great Britain.

Twenty-five years ago detailed studies of the insect and fungus diseases of the sugar-cane were the chief feature of the work of the sugar experiment stations in Java. These are now no longer considered necessary as experience has shown that the best method of dealing with sugar-cane diseases is by the efficient cultivation of suitable varieties. To grow the right kind in the right way is found in practice to be the most important factor in the control and elimination of the pests of the sugar-cane. This experience is most significant. The Java sugar industry is perhaps the high-water mark of tropical agriculture and owes its present position to various natural advantages which have been developed to the utmost by the efforts of a succession of highly qualified scientific investigators who have explored, in the greatest detail, the various directions in which the production of sugar can be increased. It is most significant that as the investigation of sugar-cane diseases became broadened and included all the factors, direct methods were given up and attention was directed solely to the variety and to its proper cultivation. This is after all only common sense. Disease follows the breakdown of the normal physiological processes in the plant when the protoplasm of the cells loses its power of resistance to the inroads of parasites. Healthy plants, on the other hand, possess a high degree of immunity to insects and fungi. It is obviously more practical to prevent disease altogether by growing the right kind in the right way than to step in at the last moment and attempt to save a moribund crop.

The problems which centre round irrigation and disease are typical of those which now await solution by the man of science. They are not simple questions and they do not lie within the limits of any one branch of science. Each involves a number of factors and it is obvious that the method of approach by means of the single science cannot hope to do more than accumulate data which may or may not be useful to some master-builder of the future. The approach by way of the single science is really an inheritance of the Liebig phase when agricultural chemistry and agricultural science were synonymous. As the subject broadened and deepened, first one and then another science became involved with the consequence that workers in these various branches of knowledge became colleagues of the agricultural chemist. The literature dealing with investigation and the teaching in the Colleges and Universities naturally followed the separate science. When about thirty years ago Departments of Agriculture began to make their appearance in various parts of the Empire, the organization was modelled on the teachings of the Colleges and the staff usually included a chemist, a mycologist, an entomologist, a bacteriologist and a botanist. As research extended, progress has always been marked by the addition of specialists whose business it was to deal with the application of some particular science to agriculture. Meanwhile the real subjects of research have far outgrown the old tradition founded on Liebig's work, and the attack by means of the single science is no longer adequate. Some new method must be devised by which science can be more fully utilized in the advancement of agriculture. If we continue as at present the organization itself will soon become a bar to progress. The immediate question is : Is there any method other than that of the single subject by which science can deal with the problems of the cultivator.

How is the difficulty to be solved and how can science be brought to bear in a more effective fashion ? Several suggestions have been made of which it is proposed to discuss two, namely team work and a widening of the training of the investigator accompanied by a gradual re-organization of existing agricultural departments. The idea of team work in the solution of agricultural problems is a comparatively recent one and is a recognition of the complexity of present day problems. Team work is another name for co-operation by which workers in single sciences can join forces to attack a complex question. It is a useful method for research institutes at which a number of graduates are working as apprentices in methods of research. By this means the post-graduate student not only has the opportunity of using his own knowledge but also comes in contact with the essential nature of large questions. In agricultural research it is an excellent method for certain centres at which experienced investigators can direct and co-ordinate the efforts of advanced students. At the most, however, team work can do little more than make the most of a bad job. It breaks down when the members of the team are isolated and are placed face to face with problems in the strange places of the earth, where the sheltered corners created by the Universities and by the endowed experiment station do not exist and where the working conditions can be summed up briefly in the three words—*payment by results.* Further, team work does not help to make investigators who can stand on their own feet. It rather tends to provide a framework for accommodating the unit very much as a regiment does. Another disadvantage is that to be effective team work always requires somebody to lead the team and to maintain direction. It also needs suitable material to lead. Team work in pure science in other countries is no new thing. It has long been common in the universities of the Continent where recognised leaders are frequently surrounded by young graduates eager to learn how to make the best use of their knowledge. At many of the Continental Universities, team work was in operation long before the term began to appear in our own literature. It is however in the study of biological problems that team work is most likely to fail. As emphasized above, the growth of a living organism like a plant involves many of the natural sciences and it is difficult to see how team work is to give that insight into vital processes without which all such research remains sterile. A successful biological investigator must be able to visualise the complicated processes taking place in a plant and to realise that such processes do not take place independently but that each influences the other. That this is being recognised is shown by the modern development at the universities of border line subjects like bio-chemistry but what is wanted is something more than this; it is an integration in the mind of the investigator of the main facts of the chief sciences which bear on agriculture.

An alternative to team work in agricultural investigation is to so widen and deepen the training and post-graduate experience that the individual can successfully attack problems now attempted by the team. At first sight, such a suggestion is liable to be ridiculed and set aside as utterly impracticable. Nevertheless I am convinced that it is the direction in which progress is most likely to be made. In putting these ideas into practice however, we are at the outset confronted with a great difficulty. On the one hand, we have to train our future agricultural investigators in several sciences so that they can bring knowledge to bear on the problem in hand from several points of view. On the other hand, as knowledge accumulates there is so much to learn that men have to specialize in one branch of science in order to avoid too long a period of training. There are thus two opposing tendencies to be reconciled. Men who can integrate and who can apply several sciences to an art like agriculture are constantly needed for all kinds of applied work. To advance pure science the specialist is also essential. How far can these two different classes be trained together and at what point must they begin to follow different roads ? This is a matter of organization of teaching in the Universities. It is one which needs the most careful thought and one which will have to be solved if we are to reap the full harvest from the application of science to industries. Up to the present, the application of science to agriculture, although successful in many instances, nevertheless has not always led to useful results. If only the training could be broadened and the right type of man with the ideal combination of knowledge and aptitude could be set to work on the problems of to-day, it ought to be possible to accomplish more in the next generation than has been achieved during the last hundred years. The problems have been defined and are before us awaiting solution. The scientific knowledge and the ability exist in the great republics of learning. In many cases the means for doing the work have been provided. What is needed is the happy union of all these factors—the trained investigator, the problem and the means.

ALBERT HOWARD

Section of Agriculture.

President:—G. S. Henderson, N.D.A., N.D.D.

Presidential Address.

I have much pleasure in welcoming the delegates to this meeting and trust that the present session will result not only in the digestion of the very valuable papers which have been contributed but also in fruitful discussions on the points at issue. The present time is one of great importance to agricultural interests in India. More prominence is being given to the study of agricultural conditions and problems in India by Government than at any time in the past; it is recognising that agriculture is our fundamental industry. Lord Reading said in a recent speech: "As I grow older in my service to India, as I learn to understand her (India's) problems, as I perceive more keenly the anxieties of India, I come more and more to the conclusion, aided and assisted by those who have the knowledge and experience, that the great industry of India, to which India must look for her regeneration and her prosperity, is her agriculture; and we must do all we can to further it." This will certainly mean the strengthening of the Provincial Agricultural and Co-operative Departments. Under the Reforms Scheme, agriculture is now a transferred subject and the Provincial Departments of Agriculture are entirely under the jurisdiction of the local Provincial Councils. Whether this change will prove in the long run successful, I would not venture to forecast. It was in any case a somewhat drastic step to take with young departments, and this departure will certainly entail some difficulty in organizing and strengthening the hands of a central co-ordinating body.

My predecessor, in his presidential address of last year, dealt with some aspects of the work of a Provincial Deparment of Agriculture. He particularly laid stress on the results obtained by the plant breeder in raising the standard of crop production. It is obviously a fact that district research and propaganda is the fundamental work of the Agricultural Department. This combined with cattle breeding and the study of farm machinery, implements, well-boring, principles of rotation, upkeep of fertility, manures and manuring are the aspects most prominent to the average observer. Very much more than this, however, is represented or should be represented in the activities of an Agricultural Department. I wish to put briefly before you the possible scope of a modern Agricultural Department, in order to obtain the benefit of your views on this very important subject at a somewhat critical moment in the history of the agricultural movement in India.

In considering this subject, it is necessary to use with care the term "Indian Agriculture." There is really no such thing, and people are apt to imagine a homogeneous whole when such a thing does not exist. Agricultural conditions vary more in different tracts of India than between Finland and the South of Spain. There are large areas of famine-stricken land and areas of marvellously rich land giving three rich crops annually in the alluvial deltas of the South, and contrasts like the rich paddy land of Bengal and the arid wastes of Rajputana. Districts there are where the price of agricultural land may be a thousand rupees an acre, and others where land may be got for a few rupees. There are districts where money is plentiful, where the most modern agricultural machinery can be found and where any practical and proved agricultural improvement is likely to meet with a ready welcome, while there are others where agriculture is still in the most primitive state.

I should like to deal at the beginning with some of the common criticisms of the work of Agricultural Departments in India. The most general one is that the experiment stations are too elaborate, the buildings much too expensive and the whole system unlikely to do any good, as these farms cannot be copied by the average ryot. These stations are in most cases for research purposes; they are field laboratories, and as such are not meant to be copied by the ryot. Their duty is to get results and these results have to be translated into practical agriculture, probably one or two simple recommendations at a time which by means of the district propaganda staff are in turn demonstrated in the villages. The buildings, too, are not the affair of the Agricultural Department. They are type designs built by the Public Works Department in accordance with Government rules; in most cases, the Agricultural Department has no power to modify them. The staff also has got to conform to Government rules, and the whole establishment becomes much more expensive than a similar concern run by private enterprise.

Another criticism is that the ryot still keeps to his traditional methods and seems to be unaffected by the presence of improved methods in his district. This, to a certain extent, is undoubtedly true. But the reasons are obvious. First, it is merely a matter of proportion. A few experiment stations can have only a very slow effect on the vast area of even a single district. The means must bear some proportion to the end required. There are more than 225,000,000 acres cultivated in British India, so a hundred farms or so are quite inadequate to leaven such a large mass. Secondly, a considerable proportion of the agricultural population of India is on the border line of extreme poverty; a good monsoon puts them slightly above this line and a deficient rainfall sends them right below the line.

In many cases they are bound by the cast-iron fetters of their economic environment such as fragmentation of holdings, debt, diseases of man and cattle, etc., so that better farming is in their case an impossibility until their general economic state is ameliorated. "Hasten slowly" is an invaluable motto in these circumstances. The ryot, especially in tracts liable to periodic failure of rain, has established a nice equilibrium between his available manure and his crop output. His traditional methods have the experience of years behind them and are not lightly to be disturbed without the greatest care and possibly in the first place by the alteration of his economic circumstances. Irrigated areas are the bright spots in India's agricultural economy. Where irrigation is possible there exists enormous possibilities of agricultural achievement.

Other criticisms that I have read in public papers are that landlords are getting poorer and poorer, so that they are unable to live on their land and have to seek for their livelihood in the large cities. The Agricultural Department is blamed for being unable to show them quick and easy ways of making money out of their holdings. The Agricultural Department is also being blamed for the present state of the milk supply in the large towns of India. Now both this town-ward flight of the "bhadraloke" from the country and the state of the cities' milk supply, have an important common factor, and that is the practical difficulty of direct cultivation on a large scale. In India, land is generally cultivated on the "batai" or share system. The actual cultivator may give up half the produce of the land to his landlord for rent. In some cases an agreement is made with a cultivator for one crop only, in others for a period of years. In Bengal, etc., where the Permanent Settlement holds, the landlord, unless he is also the occupier, has no power over the cropping of the land whatever. He simply collects a certain money rent annually, and so long as this rent is paid he can do nothing whatever to the land. Under such conditions it is obvious that the Agricultural Department can give him very little help. In other countries, where direct cultivation is the common practice, a considerable amount of experience, capital, technical and business ability are required to make a success of direct cultivation or stock breeding. There is nothing in India corresponding to the rent-paying tenant farmer farming, say, 400 acres and working 6-7 pairs of horses and hiring agricultural labourers and piece workers. The "batai" system is of course a much simpler proposition; a tenant with a pair of bullocks will take up 10 acres of crop, and in most cases tenants will do reasonably good work for a half share of the produce. Where direct cultivation is employed the capital required is enormously increased, large pay sheets are needed, dead and live stock, agricultural machinery, etc., are all necessary, and business ability of the highest order is absolutely vital to make a commercial success of such a proposition. The examples of direct cultivation on a large scale are very few and far between in India, except in the case of plantation crops such as rubber, tea, etc., where the conditions are entirely different, involving large capital with small areas, big labour forces, intensive cultivation and trained technical staff.

It is to be noted that no educational institution can teach the business side of practical farming. A degree in Agricultural Science does not mean that the holder is capable of making a financial success of an agricultural estate any more than a degree in Commercial Science signifies that the recipient could run a commercial business successfully. In recent years there have been many examples of derelict companies, generally owing to the fact that the above principle has not been recognised. Direct cultivation, especially in sparsely populated areas, is a difficult undertaking. For the production of milk on modern lines, direct cultivation for producing fodder is necessary, and this is probably one of the chief reasons for the deplorable state of the milk supply in the big cities of India. The price of milk probably reaches a world's record in Calcutta and Bombay, though in the districts at some seasons of the year there is often a flush of milk and these periodic flushes can only be utilized by extracting butter fat in the shape of ghee.

This explanation is necessary to make it manifest that not only is research required through laboratory and field experiments, but there is a crying need for practical investigation into the technique of direct cultivation in India on an estate scale.

The present constitution of the Agricultural Department in India under the Central Government consists of an Agricultural Adviser with his establishment and the following technical sections at Pusa in Bihar :—Agricultural, Botanical, Bacteriological, Chemical, Entomological, Mycological. There is an Institute of Animal Husbandry and Dairying at Bangalore and farms at Wellington and Karnal. The Agricultural Adviser is also ex-officio Chairman of the Indian Central Cotton Committee. He is also represented on the Sugar Committee and the Cattle Bureau; at present the latter bodies are still in a transition stage.

There is an advisory body called the Board of Agriculture which meets annually. The present Board of Agriculture is chiefly composed of official representatives from the various Provincial Agricultural Departments along with veterinary, co-operative and other officers. The Board meets alternately at Pusa and a provincial centre. Of late years it has deliberated on general questions put to it either by the Government of India or suggested by members. The proceedings are published but are not generally known to the public.

A general feeling has been expressed that some agency having a wider sphere of influence is now necessary to keep in touch with expansion of modern agricultural methods. Besides the education of public opinion on general questions pertaining to agriculture, there is a large field for an influential body to exercise influence on problems of national importance. With the present system of decentralization many of these problems cannot be taken in hand till public opinion can be brought to bear on vested interests. To take one example—the wheat export trade of North-West India, this still goes on in the old wasteful methods; bags are used instead of elevators with heavy expenditure in railways, docks and shipping and consequent lowering in net gain to the cultivator. Very dirty wheat is exported mixed with barley, rape seed, etc., and hard red and soft white wheat mixed.

Among the other advantages which might be expected to result from the working of some central body might be the attraction of capital to agriculture. At present both indigenous and foreign capital are very shy of agricultural projects though there is plenty of money available for special crops such as tea. India is a large exporter of raw materials; it would be greatly to the benefit of the country if bones, fish, grain and oil seeds were used and worked up in the country. The way to get this done is to influence public opinion. While, as already mentioned, owing to economic circumstances, many parts of India present great difficulties for immediate agricultural improvements, there are many other special areas where there is plenty of money and the time is ripe for improvement. The following heads represent the lines which urgently require exploiting in a national manner and which are common to two or more provinces or States :—

1. *New and improved cultural methods.*

While these are largely a work of provincial departments, there are many problems which would better be properly investigated by common action such as reclamation of *kalar*, *usar* and alkaline lands.

2. *Irrigation facilities: both canals and wells.*

National problems are the "duties of water," water requirement of crops and data for the operation of new canals, also power well bores and drainage problems.

3. *Implements and machinery.*

Efforts should be made to get foreign makers interested in India. The agency system at present in vogue has nothing to recommend it, and among other disadvantages stocks of spare parts of machinery sold are inadequate. A power threshing machine suitable for Indian requirements is one of the pressing problems of the day. In big wheat tracts the harvest of wheat is now beginning to interfere with the sowing of cotton.

4. *Improved seeds and crops.*

Under this head there are infinite possibilities.

5. *Manures.*

A large amount of work is required herein especially in the utilisation of manurial cakes, bones, fish, etc., which are at present exported.

6. *Cattle-breeding.*

India possesses some of the finest of cattle, both draught and dairy types, suitable for the tropics. It also possesses what are probably some of the poorest specimens of the bovine race. India might become a large cattle supplier for the tropics.

7. *Grading of agricultural produce especially for export.*

Little or nothing has been done in this line in the past. Other countries have put their house in order as witness dairy and fruit trade in Australia, graded and supervised by Government, also Canadian graded wheat. Most of India's products are a bye-word for dirt and inferiority in the world's market.

8. *Educational.*

The education of the right stamp of men with some knowledge of conditions in several provinces is essential for the eventual establishment of an Indian Agricultural Department staffed by Indians. Modern dairy and cattle works can also conveniently be dealt with by some central establishment.

These briefly are some of the lines of work which can only be adequately dealt with by some organization run by the Central Government and having adequate means and staff at its disposal.

The constitution and object of the proposed central organization will have to be worked out in detail. It will be essential to have a permanent Secretary and Board of Directors and the headquarters will have to be in touch with the Government of India. Transactions should be published perhaps based on the present Agricultural Journal.

It may be found possible and desirable to hold an agricultural show on a scale properly representative of the magnitude of Indian agricultural interests.

There are many models to choose from in various countries such as the United States Department of Agriculture which is largely executive in character. In the United States of America, the Federal Government corresponds to the Government of India, while each State has its own machinery corresponding to the various provinces of India, so conditions are somewhat analogous.

As noted above, the fact that agriculture has been made a transferred subject under the Provincial Councils, entails a certain amount of difficulty in organizing a Central Co-ordinating Authority. The newly elected Legislative Councils may consider that the provincial aspects of agricultural improvements are more important to them than any ideas of a national significance. It is essential therefore that it should be clearly laid down at the beginning that there will be no attempt to interfere in any way with the domestic policy of any province. On the other hand, as soon as a problem becomes of importance to two or more provinces or Indian States, it is essential that this problem must be dealt with by some central representative body.

It would also be desirable that provision should be made in the central body to give adequate representation to provincial interests.

My personal opinion is that the organization of the Department of Agriculture of the United States of America should be closely studied; and a similar organization elaborated for India with such modifications as are necessary owing to different conditions. In the United States, there are State Departments of Agriculture which are analogous to the Provincial Departments of Agriculture in India. There is a Federal Department which is financed by the Central Government. A modification of this system might possibly be found necessary, viz., to incorporate a strong propaganda and advisory section of the Central Department; on this local land-owners and private zemindars and others interested in agriculture could be enrolled.

It would also be essential to enlist representatives of the trade interests. In the case of India this is comparatively simple as the particular trades are localized. The trade interests would be better represented by the formation of Committees and Central Bureaus on the model of the Central Cotton Committee stationed at Bombay. Each important crop might have a similar organization and so also cattle and manures.

The central body could delegate its authority to a considerable extent to these various bureaus and committees, when they are in working order.

Abstracts of Papers.

1. Certain distinguishing characters of Mysore American IV. —*By* V. N. RANGANATH.

Mysore American IV is a new form of Doddahatti, the development of which was traced in a paper read at the last Science Congress.

This new variety is breeding true, during the last three seasons, and it is proposed to distribute its seed, next season.

In order to see if there were any characters which distinguish the new variety from the local one, observations on both the varieties were made and the following are the characters in which the two differ:— (*a*) Hypocotyledon and the cotyledonary leaves, (*b*) Leaf-shape, (*c*) Involucral bracts, (*d*) Size of flower, (*e*) Shape and size of fruit, (*f*) Quality of lint; (*a*) and (*b*) will be able to help the ryot to purify his field in early stages alone.

2. The distribution of mineral matter in the Cotton plant at different stages of its growth.—*By* B. VISWA NATH.

Cotton plants were pulled out at different stages during their growth and analyses made of the different parts *e.g.*, root, stem, leaves, etc.

The production of dry matter by the plant occurs at an accelerated rate during the period of growth corresponding to the formation and maturity of bolls. This accelerated growth is due mainly to boll formation and development.

The increase in the mineral content of the plant keeps pace with the increase in dry matter and an accelerated rate is evident also during boll forming period indicating a strong pull on the mineral constituents of the soil. The pull is strongest on lime.

A study of the relative concentration of the mineral constituents in the different parts of the plant points to the following conclusions:—

(*i*) Lime accumulates in the leaves during the stages of flowering and boll formation and development after which it moves on into the flowers and young bolls. It seems to be largely concerned in the formation and maturity of bolls.

(*ii*) Nitrogen and potash seem to be most in demand during the early stages of growth, the demand for phosphorus coming later during the branching and flowering stages. The amounts of soil constituents removed from the soil by the cotton crop per acre have been computed. Part of this is lost to the soil as lint and seed but much of the mineral matter could be returned to the soil as ashes. The Nitrogen however should be made good *in toto*.

3. Tractoring in India.—*By* W. M. SCHUTTE.

The paper summarizes the writer's own experience with personal tests conducted in different parts of the Bombay Presidency including Sind and at Nagpur in the Central Provinces.

After describing the various types of tractors on the market and their respective advantages and disadvantages, it is mentioned that the caterpillar type is in many ways superior to the four-wheeled type for land operations, although the wear and tear would appear to be more with the former than the latter. Practically all the tractors now on the market will give reliable service if kept in repair and operated carefully. The writer therefore urges that for extensive use of tractors in India, it is necessary that spare parts and trained, skilled drivers should be easily available, and that a new type of engine doing the same if not better work than the present complicated mechanism should be evolved.

4. Fodder and fertility of land.—*By* E. H. COLE.

An account of the impressions during a recent tour of the agricultural stations and estates in England and Wales undertaken with the view of obtaining information which would assist in improving the fodder, and pasture conditions on the writer's estate and at the same time in maintaining the fertility of the soil.

5. Milk problem in India.—*By* WILLIAM SMITH.

Discussion of the present position of the milk problem in India with suggestions for its improvement.

6. Cotton in Canal Colonies.—*By* W. ROBERTS.

7. Possibilities of developing the Poultry industry in India.—*By* MRS. A. K. FAWKES.

A general survey of the present position with suggestions for improving the domestic fowl of India.

8. Artificial crossing in Rice (*Oryza sativa*).—*By* K. RAMIAH.

Artificial crossing being one of the lines of crop improvement, the actual technic of doing it has to be carefully studied and improved upon by the crop Specialists. In rice, crossing is done by first opening the two flowering glumes sometime before they normally open, emasculating them and then pollinating the stigmas. The glumes being very delicate, the artificial opening injures them in some way or other and hence even with an experienced worker, only a small percentage of success is obtained. The blooming of rice is brought about by a particular set of conditions, the atmospheric temperature being probably one of the most important. In Coimbatore the paddy varieties start blooming at about 9 a.m. and have an intensive flush at about 10, when the atmospheric temperature is about 82° to 84° F. It has been found that if the optimum temperature is produced artificially earlier than the normal time in the atmosphere surrounding the panicle, the flower opening starts, and the anthers come out intact without dehiscing. This is an advantage, since, emasculation which is the more difficult portion of the crossing operation, is very much simplified. The simple method adopted to raise the temperature is to enclose the panicle in an ordinary brown paper cover used in the Government Offices, an hour before the normal opening starts. In about 10 to 15 minutes depending upon the intensity of the sun, all the spikelet's of the panicle which are to bloom that day are found to have opened in a flush without the anthers dehiscing. This method was adopted on a small scale last year in the Paddy Breeding Station, Coimbatore, with significant success. The method is very simple and can be followed by anybody. This method is particularly useful where testing of the viability of the pollen, ascertaining the period during which the stigma is receptive etc., are involved, necessitating crossing work on a large scale.

9. A case of 'Dimorphism' in Rice spikelets.—*By* K. RAMIAH.

In connection with the study of the inheritance of characters which is one of the lines of work pursued in Paddy Breeding Station Coimbatore, several artificial crosses had been made between different varieties and their progeny followed up for a number of generations. One of these groups under study was the progeny of a cross exhibiting 'Gametic Coupling' of more than half a dozen independently inherited characters all coming together always as if a single mendelian factor was responsible for their expression. Some of the important characters coming associated in this group are a deeply pigmented blackish looking internode, similarly pigmented fertile glumes and black rice. In this family one aberrant type or "cross over" was obtained where the plant had the dark internode, and dark glume but white rice. To get a type fixed a number of selections had been taken out of this and grown for three or four generations. Though the progeny was pure for white rice, no pure type could be obtained with dark internode, dark glume and white rice, the selections always throwing out plants with lighter internodes and green glumes. In this family again one plant was accidentally met with last year where, the dark glumed spikelet together with its allelomorph the green glumed spikelet, were appearing separate in the same panicle and even in the same spike. The plant was carefully marked and the grains were harvested separately and we have the crop growing in the field this year. It was first thought that the phenomenon may be a case of 'Somatic Segregation' but the behaviour of the progeny does not warrant this theory and the study on these is being continued.

10. Chlorophyll deficiency in Rice seedlings.—*By* K RAMIAH.

The occurence of the completely white seedlings in Rice has been recorded before, and definite 3 : 1 and 15 : 1 ratios of normal green to white seedlings have been obtained among other more complicated ratios. Another character has been noted recently in the progeny of a cross where the seedling remains pale yellow with foliage of definitely lighter colour than the normal green. The difference in colour is very marked in the early stages, and gradually disappears as the plants get older. The pale seedlings are definitely less vigorous and slower growing than the normal greens, but unlike the pure whites which all die off very early, these attain maturity and yield grain alright. When a few of these pale yellow seedlings were isolated and their seeds sown, again, only pale yellows resulted showing the character to be a mendelian recessive. A few greens, 8 in number, appearing in the pure yellow beds were suspected as natural crosses and when these were isolated and their produce sown separately, segregation into green and pale yellow was recorded, but the ratios of green to pale yellows are not definite except in one case which may be taken as a rough 3 : 1. To find out the number of mendelian factors involved, a definite artificial cross was made last year between a green and a yellow both breeding pure, and the F_1s in the fields being all greens. Another cross made between a pure yellow and one of the green natural crosses noted in the yellows has given F_1s some green and some yellow as was expected.

11. Some current problems of cane growing and sugar production in India.—*By* WYNNE SAYER.

This paper deals with the important sugar industry in India and the possibilities of producing a larger output of white sugar in the country.

12. The present position of sugar industry and the possibilities of sugar beet in India.—*By* P. B. SANYAL.

In spite of her very large production India imports about 400,000 tons of sugar annually mainly from Java. The amount of import increases with the fall in the price of sugar which takes place when the production of beet sugar in Europe and America increases. During war time when beet sugar manufacturing centres in Europe were dislocated India got a chance of developing her Sugar Industry. With the revival of beet sugar industry in Europe after peace India is once again faced with the danger of losing her sugar industry In spite of her having a vast area under sugarcane, the advantage of the local consumption of all the sugar she produces, valuable government help in establishing a cane breeding station and Sugar Bureau, appointing a Committee to enquire into the causes of India's draw-backs, and imposing a duty on the imported sugar, India is still unable to compete with the foreign countries. Besides their inefficiency the Indian factories are handicapped in not getting full supply of cane for a long period owing to her climatic difficulties in Northern India where a large majority of them are situated.

If cane alone cannot succeed in competing with the foreign countries attempts should be made to manufacture sugar from sources other than cane. Experiments with date palm are being tried in Bengal. Sugar-beet was successfully grown in N.W.F.P for a number of years. Two years' experience in growing the crop at Pusa convinced the author that it can be grown in many other parts of India whose climatic and soil conditions satisfy the requirements of the crop. The first year's results of Pusa experiment are published in the Agricultural Journal of India (1925, Sept.). The second year's results are still more promising. They show that sugar-beet of good quality and yield comparing favourably with Europe and America could be grown in Tirhoot from imported seed as well as that collected at Peshawar.

It is significant that the beet season closely follows that of cane in Bihar. Compared to her production India's import is less than $\frac{1}{7}$th. It is therefore suggested that if the existing factories in Bihar, with some modifications of the appliances, take to the manufacture of beet sugar there may be a possibility for India to make up her deficit and even to export sugar in the foreign countries.

13. Maize.—*By* R. D. BOSE.

A general survey of the distribution, cultivation and general agricultural details of this important crop in India.

14. Refrigeration and its use for tropical fruits.—*By* S. K. GANDHI.

It is pointed out how by means of refrigeration or thermal control in an insulated store house, the fruits could be preserved in their original freshness, for a pretty long time. Extremely perishable fruits could be preserved from the season of plenty to that of scarcity bringing good profits to the businessman. The paper is a brief account of the author's observations on the keeping quality of some tropical fruits such as mangoes, bananas, chikus, and papayas in cold storage. In the course of discussion it is brought to the notice of the reader, how seasonal fruits like mango could be profitably stored in the cold storage. The whole account deals with the cold storage plant recently installed at the Crawford Market, Bombay. This cold storage plant for the present stores in its fruit chamber only semitropical and temperate fruits. Tropical fruits like mango could not be stored due to low temperatures maintained for temperate fruits. The author by experimental evidence shows how the tropical fruits require a much higher temperature than the temperate and semitropical fruits to keep in the cold storage. It is finally concluded that a steady and uniform temperature somewhere round about 45 F. will suit the tropical fruits like mango, bananas, chiku and papaya, and that any temperature below 38° or 40° F. will seriously affect them.

15. Dehydration of Deccan vegetables and fruits.—*By* P. G. DANI.

The question of drying of vegetables when they are very cheap is coming prominently before the public. Drying in the sun is comparatively a simple process; but when sundrying is not possible, dehydration of vegetables and fruits in special evaporators becomes a necessity. Such an evaporator was borrowed from Mr. B. M. Basrur of Honavar, Proprietor of the Mango Canning Factory of Ankola for trial at Modi-Bag. Its name is American Evaporator No. 2. Its construction is simple. There is a cast iron body surrounded by galvanised iron sheet jacket leaving all round a space of about 6″ for the free movement of the air which rushes in through the bottom. On the body rests a wooden drier consisting of two chambers. The placing of the evaporator is so arranged that no heated air passes out except through the chambers. These chambers hold sliding trays on which the material to be dried is spread. The oven arrangement is made in the body itself and there is a separate chimney for the smoke to be let out. As the air comes in contact with the outer surface of the heated oven, it gets hot and being light tries to get out through the chambers. In this way a regular draught is set in the machine. The temperature varies directly with the quality of fuel used. By regular feeding constant temperature can very well be maintained with a little experience. The material before it is placed for evaporation, is steamed or soaked in boiling water for a few minutes. This process is called blanching.

In this way trial was given to cabbage, cauliflower, brinjals, gowar or cluster beans, bhendi or lady's finger, peas and bananas, and in each case the result was very successful and promising.

16. Control of the Coconut caterpillar (*Nephantis serinopa*)—by its parasites. *By* Y. RAMACHANDRA RAO.

Nephantis serinopa is a serious pest of coconut in many parts of S. India. It also breeds in other palms such as the Palmyrah, the Talipot, and the Wild Date (or the Toddy) palm. A serious infestation of the pest was reported in 1921 at Mangalore. Endeavours were first made to control the pest by systematic cutting and burning of infested leaves, the aid of the Pest Act having been invoked later on for the enforcement of the measure.

As the benefits derived from this method were found to be only of a temporary nature, the question of the possibility of a natural control through the natural enemies of the pest was investigated. Instances of such a natural control of this pest through its parasites were brought to light in many places in the plains of the East Coast Districts. On examination this was found to be due to the joint work of four different parasites:—(1) a Chalcid (*Stomatoceras sulcatiscutellum*) attacking the pupa, (2) a Braconid (Apanteles sp.) ovipositing in half-grown caterpillars, (3) a Bethylid—attacking full-grown caterpillars, and (4) an Elasmid (*Elasmus nephantidis*) breeding in caterpillars just before pupation. As at Mangalore the first parasite (*Stomatoceras*) alone was present, consignments of infested leaves containing live cocoons of the parasites were despatched from time to time and liberated in large parasite cages at Mangalore. At the end of about a year, the establishment of two of the larval parasites was noted at Mangalore and a perceptible decrease in the numbers of the pest was observed to have been brought about.

Endeavours are being made to distribute the parasites into the interior of South Kanara where the pest has now spread. Life-history notes of the different parasites are given so far as known.

17. Utilization of Mahua waste as manure.—*By* MEHDI HASAN *and* HABIB HASAN.

India produces an enormous quantity of Mahua flowers from which country liquor is distilled. The residue left after distillation is nearly all thrown out from our distilleries as useless. Experiments were tried to find out their manurial value for field crops. In pot culture experiments barley and wheat gave a very good response. Results of nitrification carried out side by side show that Mahua Waste is slow in nitrifying.

The increase in yield of crop (grain and straw) cannot be attributed to the nitrogen added. Determination of physical factors showed an increase in the moisture holding capacity of sandy soils as compared with controls.

18. The oxidation of Sulphur in suspensions of activated sludge and its influence on the solubilisation of mineral phosphates.—*By* C. V. RAMASWAMI AYYAR, T. S. S. PERUMAL PILLAI, *and* ROLAND V. NORRIS.

A study has been made of the oxidation of sulphur in suspensions of activated sludge under various conditions with special reference to its influence on the solubility of mineral phosphates. The suspensions were kept under aeration for about twelve weeks, samples being taken for analysis at intervals of ten days and determinations made of p H, titratable acidity, SO_4 and water soluble phosphate. The acidity resulting from the sulphur oxidation leads to a rapid increase in the water soluble phosphate when pure tricalcic phosphate is employed. If "flour phosphate," the impure calcium phosphate found in the deposits at Trichinopoly, be used the amount rendered soluble is very much less, calcium carbonate being attacked instead. This doubtless explains the slow action of flour phosphate when used as a manure.

In control experiments without sulphur the p H remains in the range 7·8 to 6 and nitrification proceeds vigorously. In the sulphur series without added phosphate, the acidity rapidly increases to a p H of 1 6 and nitrification is inhibited. When phosphates are added these act as buffers and the p H figure remains about 4·6, phosphates being steadily dissolved as more acid is produced.

Certain salts, e.g. ferrous sulphate and aluminium sulphate, when present in small quantities, have a beneficial effect, increasing the rate of acid formation and consequently leading to more rapid solution of phosphate.

19. The isolation and study of Sulphur-oxidising Organisms from activated sludge.—*By* C. V. RAMASWAMI AYYAR.

"Activated Sludge" serves as a good source of sulphur-oxidising bacteria. If a suspension of sulphur and activated sludge be aerated there is a rapid development of acidity until the p H reaches about 1.6. At this degree of acidity most of the organisms, except those responsible for the sulphur oxidation, are eliminated and it is easy to isolate the latter. Pure cultures have been obtained in this way and the characteristics of the organism investigated.

20. Studies on 'Intensive Nitrification.'—*By* S. RANGANATHAN (*Senior.*)

This is a continuation of work presented before the Science Congress at Bangalore by Kotwal. Experiments were continued to find out the maximum concentration of nitrates producible by bacterial oxidation of ammonium salts, applying the principle of the activated sludge process. With dilute solutions of ammonium salts and with calcium carbonate in quantity necessary to neutralise the resulting acid but employing no nutrient salts, a concentration of 5·56% of calcium nitrate was obtained. The intensity of nitrification gradually decreased with increasing amounts of calcium nitrate. Beyond a concentration of 5·56%, the nitrifying organisms, though living, ceased to function normally. In the presence of salts of iron and phosphorous concentrations of 7·55% and 7·44% respectively were obtained. Even in the experiments where a nutrient solution of ammonium sulphate was employed alternately with a solution of ammonium carbonate containing an equal amount of ammoniacal nitrogen, it was not found possible to obtain more then 7·5% of calcium nitrate. The influence of salts such as $MnSO_4$, $FeSO_4$, $CaSO_4$ was examined with the result that $FeSO_4$ up to a concentration of 0·075% was found to be very beneficial. Silt, animal and wood charcoals were also tried to increase the surface effect, animal charcoal aiding nitrification to the greatest extent. The latter was by itself able to oxidise $(NH_4)_2SO_4$ in small quantities even under perfectly sterile conditions, aeration accelerating the process. In the case of bacterial oxidation also aeration exerts a profound influence producing up to 25 times the nitrate found in the unaerated control. In regard to the calcium carbonate requirement for efficient nitrification the theoretical quantity necessary to neutralise the acid produced is enough and higher amounts of calcium carbonate may result in increased loss of nitrogen. The nitrifying organisms thrive in media of which the p H lies between 5·8 and 8·0, but function best when p H is between 7 and 8.

21. Ammonification by Soil Fungi.—*By* A. K. THAKUR.

The part played by fungi in the breaking down of organic matter in the soil is probably an important one. An account is given of the nitrogen metabolism of three species of fungi, *Aspergillus*, *Penicillium* and *Mucor* under different conditions. The cultures have been made in an artificial medium in which gelatine was the source of nitrogen. Samples were removed every third day and the nitrogen distribution examined. Determinations of p H were also made. Ammonia production appears to take place in different stages. During rapid vegetative growth, though the protein nitrogen diminishes little ammonia appears in solution, the nitrogen being retained by the organism. Later, as vegetative growth diminishes and spore formation takes place, there is a rapid accumulation of ammonia. A third stage is reached when the concentration of ammonia remains more or less constant, the nitrogen required for now growth being probably provided by the autolysis of older cells. The influence of carbohydrates on the above processes has also been studied.

22. Gum-formation by Soil Fungi.—*By* A. K. THAKUR.

During the course of an attempt by the author to investigate the intermediate products formed during the oxalic and citric acids fermentation of carbohydrates by soil fungi together with the mechanism of their formation and their biological significance it was observed in the case of one species (Mucor) that the culture medium during growth became syrupy and highly viscous. The medium possessed the following composition :—

Water	1000 c.c.
Cane sugar	100 gms.
Amm. phosphate	2·5 gms.
Pot. chloride	0·2 ,,
Mag. sulphate	0·2 ,,
Zinc ,, ...	0·1 ,,

Sterilised calcium carbonate was added after one week's growth to neutralise and precipitate the acids formed in the fermentation.

The gummy substance was precipitated from the filtrate by 95% alcohol saturated with ether and its properties studied. A further investigation is being carried out to see whether it forms one of the intermediate products in the degradation of cane sugar.

23. Carbohydrate changes in the Plantain during ripening.—*By* S. RANGANATHAN, (*Junior*).

The sugars and other carbohydrates of the plantain have been examined at different stages of ripeness.

The increase in the amount of sugar and the constancy in the total carbohydrate content suggest an enzymic breaking down of the starch. In common with previous observers, however, it has so far been found impossible to detect the presence of amylase at any stage of the process.

Section of Mathematics and Physics.

President:—PROF. MEGHNAD SAHA, D.SC.

Presidential Address.

APPLICATION OF SUBATOMIC THERMODYNAMICS TO ASTROPHYSICS.

INTRODUCTION.

Before I take the chair, I wish to express my heartfelt thanks to you for inviting me to preside over this annual gathering of the mathematicians and physicists of India. But I must confess that I feel extremely diffident regarding my ability to entertain you with a topic worthy of the occasion. For we are living in an Augustan age of discovery in the physical science. Even leaving spectacular achievements of our science aside, you will probably agree with me that no period in the history of our science has been so rich in discoveries of the first magnitude as the period 1895–1920. X-rays, Radioactivity, the Electron Theory, the Quantum Theory of Radiation, and the last, though not the least, the Theory of Relativity—all these taken together constitute a revolution in human thought, a revolution which cannot but profoundly modify the future of mankind.

I have, however, chosen to speak on a subject which, in the language of the poet Heine, may be described as 'die alte, die ewig junge Wissenschaft'—the old, the ever-young science.

Let us begin with a little historical retrospect. We know that even in the dawn of civilisation on this globe of ours, astronomy had a peculiar fascination for the thinking section of mankind, and

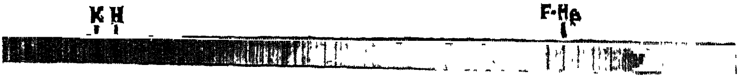
"In Babylon, in Babylon,
    They baked their tablets of the clay,
And year by year, wrote thereon
    The dark eclipses of their day,
They saw the moving finger write,
    Its Mene, Mene on their Sun,
A mightier shadow cloaks their light
    And clay is clay in Babylon."

A. NOYES—*The Torchbearers.*

You are all aware that every period of renaissance in physical and mathematical sciences has been marked by an outburst of activity in astronomy as well, and very often, the relations have been reciprocal. The recent discoveries in the physical science have been no exception to the general rule. Indeed, they have blown a new breath of life into her old frame, and in this address, I have tried to give you a picture of this process of rejuvenation.

SPECTRUM ANALYSIS.

It was just sixty years ago that Kirchoff in Germany discovered the principles of spectrum analysis. Astronomers all over the world awoke to the consciousness that an instrument with vast potentialities was placed in their hands for surveying the physical nature of the Sun, and those island universes which we call Stars. I need not tell you how they took advantage of this discovery, and found that in the dark, hitherto mysterious, lines of Fraunhofer, the Sun-god has written the story of its own constitution; or how it was established by Sechi, Lockyer, Pickering and others that from an analysis of the spectra of stars, we can draw conclusions regarding the constitution and physical nature of the stars. My story begins with the details of decipherment.



Fraunhofer-Spectrum of the Sun.
[The central part has been over-exposed and washed out.]

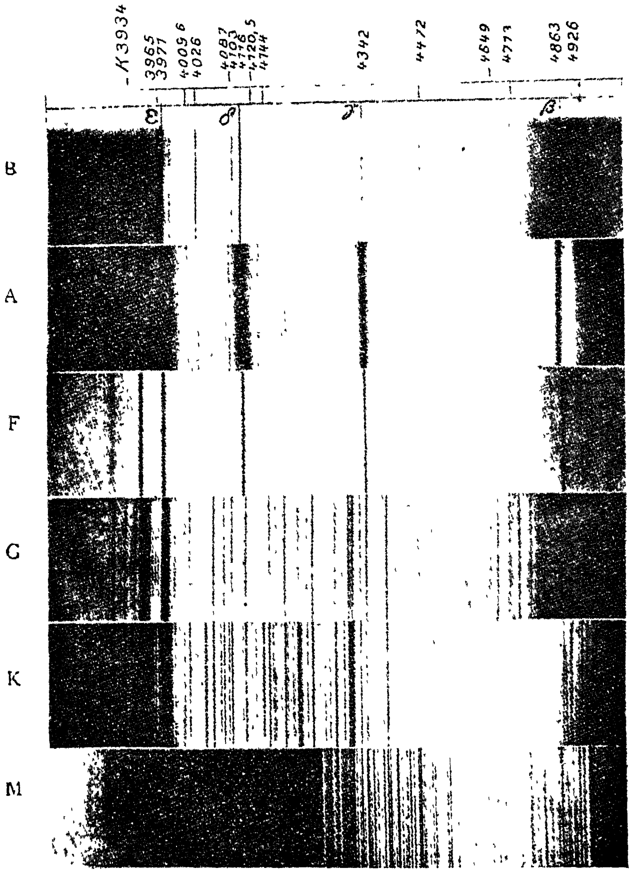
The solar spectrum contains about 20,000 dark lines of which only 6,000 can with certainty be identified with lines of 36 of the known elements. But we know that this earth of ours is composed of 92 different elements, and supposing that the earth is simply a fragment of the sun, it is only natural to conclude that the sun would also show the same number of elements.

The same difficulty presents itself in a more acute form when we turn to the spectra of stars. Yellow stars show spectra similar to that of the sun, white stars show spectra in which hydrogen lines are very prominent at the expense of metallic lines, and bluish white stars were found to show a number of unknown lines which have since been identified with the lines of helium. Lockyer, who undertook a systematic survey of different varieties of spectra of stars found that almost all stars can be subdivided into a number of well-marked groups which gradually merge into one another. The classification was confirmed by the spectroscopic survey of 200,000 stars at the Harvard College Observatory by Prof. Pickering and Miss Canon, who denoted these groups by the rather arbitrary sequence of letters

P····O····B····A····F····G····K····M····N····R····S

It became customary to speak of B-stars as helium stars, or A-stars as hydrogen stars, because most of the lines appearing in their spectra belong to these elements.

Such a designation carries with it the idea that the star in question is chiefly composed of hydrogen, or helium. The other metals whose lines are not to be found in the spectrum of the star are either absent, or not formed at all under the physical conditions prevailing in the star.



(Spectra of Different Classes of Stars—from Phys. Zeit., 1922.)

But there is an inherent difficulty in such an explanation; for if we regard the different classes of stars to be in different stages of evolution (*e.g.* let us suppose the white A-stars will in course of billion, billion years cool down and reduce to the yellow G-stage); then we must admit that they are composed of the same elements. But as we have just seen, this is not borne out by analysis of their spectra. We are therefore driven to the hypothesis that in the course of evolution of stars, there is also a parallel evolution of elements. For example, Ca is not found in very hot stars, but come out only in the cooler stages. We have then to admit that calcium is evolved from simpler constituents.

LOCKYER'S HYPOTHESIS OF INORGANIC EVOLUTION.

Such a theory was presented by the late Sir Norman Lockyer in his 'Inorganic Evolution,' and he supported his contention by laboratory experiments. Lockyer proved that the spectrum of an element was not invariable, but changes with the stimulus. A very good example is afforded by calcium which gives a line λ 4227, [called *g* by Fraunhofer] very strongly in the flame and the arc, but fades away in the spark, while two other lines, the *H* and *K* of calcium which are very faint in the flame become prominent in the arc, and completely dominate the spectrum of the spark. He found similar results in the spectra of other elements, and in the case of silicon, he found no less than four successive stages. If the atom was invariable, argued Lockyer, how do you account for these variations ?

But the scientific world, trained to the fetish of an invariable and further indivisible atom, refused to listen to the arguments of Lockyer. As I had occasion to remark elsewhere, he was like the mythical Greek aeronaut Icarus who, in trying to reach the heavens with wings of wax, had to end by falling into the sea. But such unsuccessful attempts are more important for the progress of science than spectacular successes in narrow, well-chalked out lines.

Twenty seven years have elapsed since the date of Lockyer's 'Theory of Inorganic Evolution' and within these twenty seven years, our ideas of matter, energy and other physical concepts have undergone a complete and radical change. The idea of the divisibility of the atom is no longer foreign to us; in fact, it is a matter of common knowledge now. Let us now see how these modern discoveries have led us to a solution of the difficulties confronting Lockyer, and others.

INFLUENCE OF HEAT ON MATTER.

Subatomic Thermodynamics.

We can start by considering the influence of a gradually increasing temperature on matter. At the lowest temperature all matter exists in the form of solids. With gradually increasing temperature, the parts loosen ; it first becomes liquid, then gaseous, when the molecules fly away from each other. With further rise of temperature, the molecules break up into atoms. What happens next ?

The answer to this question could be given only after the Rutherford-Bohr theory of the atom had taken a definite shape. We now know that the atom consists of a central positive charge of N (N=ordinal position of the element in the Periodic Table), surrounded by N electrons grouped in different layers. The spectral lines are due to the vibration of the outer electrons according to the quantum mechanics of Bohr. It is now easy to see that with increasing temperature, the electrons will come against each other more frequently; the electron will be displaced to higher orbits, and ultimately it will be knocked off. Taking the element calcium, the last process may be described by the chemical symbol:—

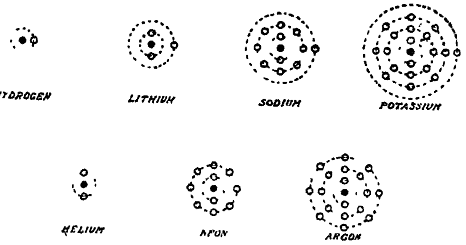


Fig. 1

$$Ca \rightleftharpoons Ca^{+} + e.$$

It is a well-known law in Chemistry that when a complex molecule, say NH_4Cl, breaks up under the influence of heat into simpler molecules, (NH_3 and HCl in the present case), then at a particular temperature and pressure, there will be a definite proportion between the number of undissociated and dissociated molecules. Guldberg and Waage, Van't Hoff, Nernst and Sackur have shown that the amount of dissociation can be calculated as a function of temperature, and pressure, provided the heat of reaction, the specific heat and the vapour pressure of the substances are known over a wide range of temperature. The idea occurred to Eggert that the same equations with some modification may be applied to calculate the ionisation of elements in stellar masses which, according to Jeans and Eddington, consisted of highly ionised atoms in equilibrium with radiation. Taking the case in hand, if we agree in treating Ca^{+}, and electrons as monatomic gases, we easily perceive that the effect of gradually increasing the heat stimulus will be first to drive the outermost electron to higher and higher orbits. This is marked by the emission of characteristic lines of Ca, particularly Fraunhofer's g line, λ 4227 which is the fundamental line of Ca. Then a certain fraction of Ca-atoms will be ionised.

At a certain temperature and pressure, there will be equilibrium between normal Ca-atoms, Ca-atoms, in higher orbits, the characteristic radiation of Ca, Ca^{+} and free electrons. The problem is thus complicated, but we assume, as a first step towards solution, that the number of Ca-atoms in intermediate stages is negligible. The fraction x of Ca-atoms ionised is given by:—

$$\log.\frac{x^2}{1-x^2}P = -\frac{U}{2\cdot 3RT}+\frac{5}{2}\log T-6\cdot 5 \qquad (1)$$

where U is now the heat of ionisation. In Chemistry, U has to be determined by a separate set of calorimetric experiments, but in the present case, U can be determined from spectral data, or experimental values of the ionisation potential, as done by Franck, Hertz, and other workers.

Formula (1) is derived on the assumption that all the electrons arise from decomposition of the original mass of Ca. In other words, the system is unicomponent. But the electron can also arise from the decomposition of other elements. Hence it is useful to consider the modification of formula (1) when the system is a bicomponent one, *i.e.* there is an excess of electrons. The equation takes the form, first given by Russell

$$\log\frac{x}{1+x}\,\frac{y}{1-y}\,P = -\frac{U}{2\cdot 3RT}+\frac{5}{2}\log T-6\cdot 5 \qquad (2)$$

Neither formula (1) nor (2) are perfect for we have not considered the mechanism of ionisation, and a number of other points which will be discussed later on. Yet, let us see, how far we can proceed with formula (1) and (2).

SPECTRA OF IONISED ELEMENTS.

The next question is how we can detect ionisation? This can be done with the greatest ease, spectroscopically. From the works of Fowler and Bohr, it is now certain that the enhanced lines of Lockyer are due to atoms which have lost one or more electrons. Thus Fowler has established that

Lockyer's *Si* I—is neutral *Si*
Si II—Si^{+} (*Si*-atom which has lost one electron)
Si III—Si^{++} (do. two ,,)
Si IV—Si^{+++}(do. three ,,)

To see the application of formulae (1) and (2), let us take the case of *Ca* cited above. According to Fowler and Bohr, λ 4227 indicates the presence of *Ca*. The *H* and *K* lines indicate the presence of Ca^{+}. If in a luminous mass, we obtain the *H* and *K* lines by spectroscopic examination, we at once conclude that *Ca* present in the mass is wholly or partially ionised. The following table illustrates how with increasing temperature, the ionisation of *Ca* gradually becomes complete.

TABLE.

Ionisation of Calcium in different Luminous Masses.

Luminous Mass.		Temp.	Int.		
			$Ca-g$	$Ca^+(K)$	$\frac{Ca^+}{Ca}$
Flame	King's	2000°	300	20	1 : 15
	Furnace	2500°	500	30	1 : 16
	Spectra	3000°	1000	60	1 : 16
	Arc	4000°	400	500	8 : 10
	Vacuum Arc	4000° (Low pressure)	8	25	25 : 8
Solar Photosphere		6500° ~ 7000°	20	1000	50 : 1
Chromosphere		5000° ~ 6000° (Low pressure)	8	75	
Sirius		10000°	Almost disappeared.	Very bright.	

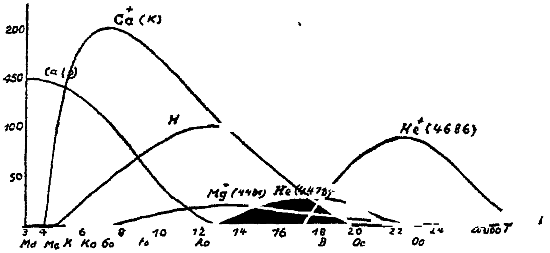
N.B.—The intensity scales are different in the different cases, and attention is to be fixed on the relative intensities alone.

There is a very close correspondence between the ionisation of calcium with varying temperature, and the intensification of the line K in the stellar classes. There is also a close correspondence between the gradual decrease in the intensity of the g-line, and decrement in the percentage of neutral Ca with increasing temperature. We are therefore justified in saying that the stellar spectra are simply a function of the surface temperature (taking pressure to be of the same order of magnitude in all cases), a view advocated for a long time by Prof. H. N. Russell.

Similar calculations of ionisation can be made in the case of all elements of which the ionisation potentials are known, and x, the fraction ionised, can be calculated as a function of T and p.

An application of above ideas lead, for the first time, to a clear understanding of the regular and continuous gradation in the spectra of stars, and thus to a physical explanation of the Harvard classification of stars. Cooler stars show only arc lines because the temperature is not high enough for ionising the elements. The enhanced lines become more and more prominent in the hotter stars, because with increasing temperature, ionisation becomes more complete. From the marginal appearance or disappearance of lines of Ca, Ca^+, Mg, Mg^+, Na, Sr, Sr^+, He, He^+, ..., it is possible to obtain rough values of the temperature of the stars. Values obtained in this way are in agreement with the results obtained by King, Wilsing and Scheiner by more direct methods.

We are also led out of the difficulty mentioned in the outset, viz. why in the hotter stars, only lines of H, He and certain light elements are prominent, and metallic lines entirely disappear. This is so because at the high temperature prevailing in the star, the metals, owing to their low ionisation potential become entirely ionised while *H* and *He* become only

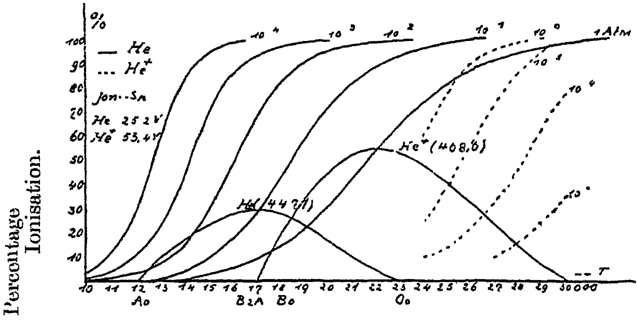


Curve of intensity of *Ca*-, *Ca*⁺ -, *H*-, *Mg*⁺, *He*-and *He*⁺ lines according to Harvard Publications Ordinates are in arbitrary units, abscissa represent spectral classes and the temperature are those given by Saha (taken from an article by *R*. Emden in the Phys. Zeit. (1922).

luminous. Thus the tendency in former years, to label these stars as hydrogen or helium stars, must now be given up. There is no reason to suppose that the chemical composition varies materially from star to star.

INFLUENCE OF PRESSURE ON IONISATION.

If we refer back to formula (1), we find that besides temperature, pressure has an appreciable influence on ionisation. A reduction in pressure is always accompanied by an increase in the percentage ionisation. The following table shows how the percentage ionisation of hydrogen, and helium increases with decreasing pressure :—

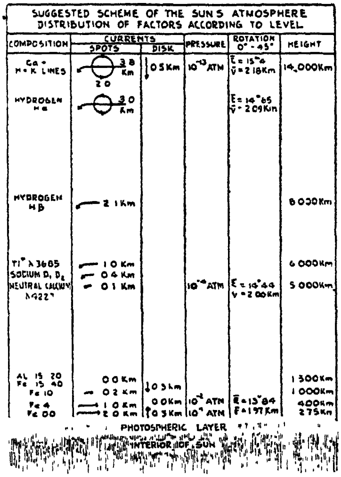


[From an article by R. Emden, Phys. Zeit. 1922.]

This simple fact provides us with the explanation of the important differences between the Fraunhofer spectrum, and the spectrum of the solar chromosphere. Lockyer was the first to find out that the two are not the exact reversal of each other, as an application of Kirchoff's law would lead us to expect. The main differences are:—

(1) Fraunhofer spectrum contains only 5 hydrogen absorption lines, viz. H_α, H_β, H_γ, H_δ, H_ϵ, while Lockyer, Evershed, and Mitchell discovered no less than 35 hydrogen Balmer lines in the flash spectrum.

(2) No helium lines occur in the Fraunhofer spectrum, while the flash spectrum shows a pretty large number. In fact as is well-known, the D_3 line was first discovered by Lockyer in the flash spectrum, and anticipating that it was due to some element still unknown on the earth, he took the bold step of christening it Helium after Helios, the Sun-god.



[Taken from a paper by St. John, Astrophysical Journal.]

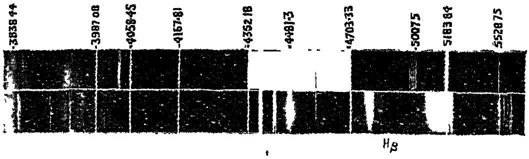
(3) The enhanced lines of all elements are more prominent in the flash spectrum than the lines of the neutral atom. They reach a greater height in the solar chromosphere than the unenhanced lines. In fact, the upper chromosphere is entirely made up of ionised elements as illustrated in Plate 7, diagram which is based on the eclipse data of Mitchell, and is taken from a recent paper by St. John.

Lockyer expressed these results by saying that the spectrum of the flash was similar to that of the hotter star, α-Cygni, class gA_2. Thus in terms of temperature, the chromosphere shows as large a stimulus as a temperature of 10000°K, while on the photosphere, the temperature cannot exceed 7000°K.

The enhancement of stimulus on the chromosphere is of course unquestionable, and Lockyer did not hesitate to assert, that the temperature of the chromosphere was higher than that of the photosphere. But the analogy was pushed too far, and he said that the temperature of a star decreased inwards and that the interior might be quite cold. But he failed to convince anybody of the correctness of his arguments.

The ionisation theory leads easily out of this dilemma. The enhancement of stimulus in the chromosphere is due, not to increased temperature, but to reduction in pressure, and this takes place in spite of reduction in temperature

That reduction in pressure may give rise to enhancement of stimulus has been definitely asserted by Mitchell in 1913 in his study of flash spectra, and Fowler and Payn had actually given an experimental proof of it as early as 1903. They showed that the vaccum arc of *Mg* gives the enhanced line λ4481, while the ordinary arc does not show a trace of it.



Spectra of *Mg* arc in air and in vacuum. Note the development of λ4481, due to Mg^+ in vacuum arc. It is entirely absent in the open arc. It is due to reduction in pressure. Taken from a paper by Fowler and Payn in Proc. Roy. Soc. 1903.

The occurrence of helium lines in the chromosphere can also be explained on the same grounds. The visible lines of helium arise not from its normal orbit, but from higher orbits, requiring an excitation potential of over 19 volts, and such a high stimulus is not present in the layer which gives rise to Fraunhofer lines. But this stimulus is produced in the higher layers owing to reduction in pressure, with the result that we get the visible lines of He in the flash. Probably experiments can be devised which will give us quantitative data regarding the difference in pressure between the usual reversing layer and the higher chromosphere.

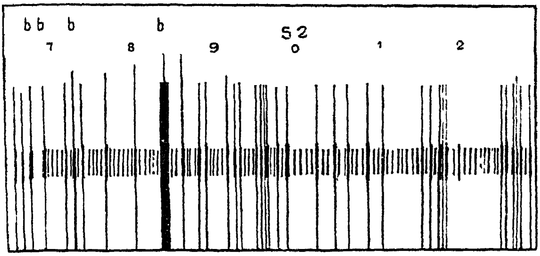
ELEMENTS IN THE SUN.

We shall now see how the ionisation theory helps us in understanding the difficulties connected with the identification of lines in the Fraunhofer spectrum, and the occurrence of only 36 elements on the solar surface.

In the alkali group, *Rb* and *Cs* are the two elements of which no lines could be found in the Fraunhofer spectrum. These two elements have the lowest ionisation potential of all, and actual calculation shows that on the surface of the sun, they would be completely ionised. The chief lines of the enhanced spectra lie far in the ultraviolet. Hence as regards the identification of these elements, we are placed, to use a rather slang expression, between the devil and the deep sea. This is true not only of *Rb* and *Cs*, but also of many other elements, because their most intense lines lie beyond the range within which our observations have to be limited.

But if any part of the solar surface undergoes a local cooling, *Rb* and *Cs* may partly return to the neutral state. This actually happens in the sunspots, for Fowler has proved that the spectra of spots is similar to that of the *K*-type of stars and hence the temperature cannot be far beyond 4000°C.

It was predicted from the above-mentioned line of argument, that *Rb* and *Cs* may occur in the spot in the neutral state. The verification of this prediction by Prof. H. N. Russell, who discovered the infrared pair $\lambda \left.\begin{matrix}7911\\7800\end{matrix}\right\}$ of *Rb* in some spot spectra taken by Dr. Brackett of the Mount Wilson Solar Observatory constitutes one of the earliest and the greatest triumphs of the ionisation theory. In recent years some enhanced lines of *Rb* and *Cs* have been indentified in the solar spectrum, so that the presence of these elements in the sun is now established beyond doubt.



Spectrum of Sunspot in the middle compared to the general spectrum of the sun. Taken from Pringsheim's Physik der Sonne.

As regards other missing elements, we come across difficulties of a nature peculiar to each element. Take, for example, the element oxygen. This is the most plentiful element on the earth and it was naturally expected that it would show very prominently in the sun. But for a long time, no trace of any line of oxygen could be found in the Fraunhofer spectrum. It was only in 1914, forty-five years after Kirchoff's discovery, that Runge identified a triplet in the extreme red which he proved to be identical with an oxygen triplet. But why did this triplet of oxygen occur so faintly in the Fraunhofer spectrum? The answer has been provided only recently from an analysis of the spectrum of oxygen. Hopfield has recently shown that the principal lines of oxygen are in the Schumann region, and hence they are entirely cut off. The lines of oxygen which can be used for identification belong to minor combinations, and require very high stimulus,—about 10 volts for their production. Hence the prospect of getting *O*-lines in the sun is very small, though the element may be more plentiful than hydrogen or calcium, the lines of which are so prominent on the sun. Similar explanations may hold for the inert group *Ne*, *A*, *Kr*, *Xe* and Nitrogen.

In fact the ionisation theory coupled with a knowledge of the constitution of the spectra of elements lead us to a complete justification of the saying of Rowland "If the earth were suddenly heated to the temperature of the sun, its spectrum would be the same as that of the sun."

SPECTRA OF FACULAE.

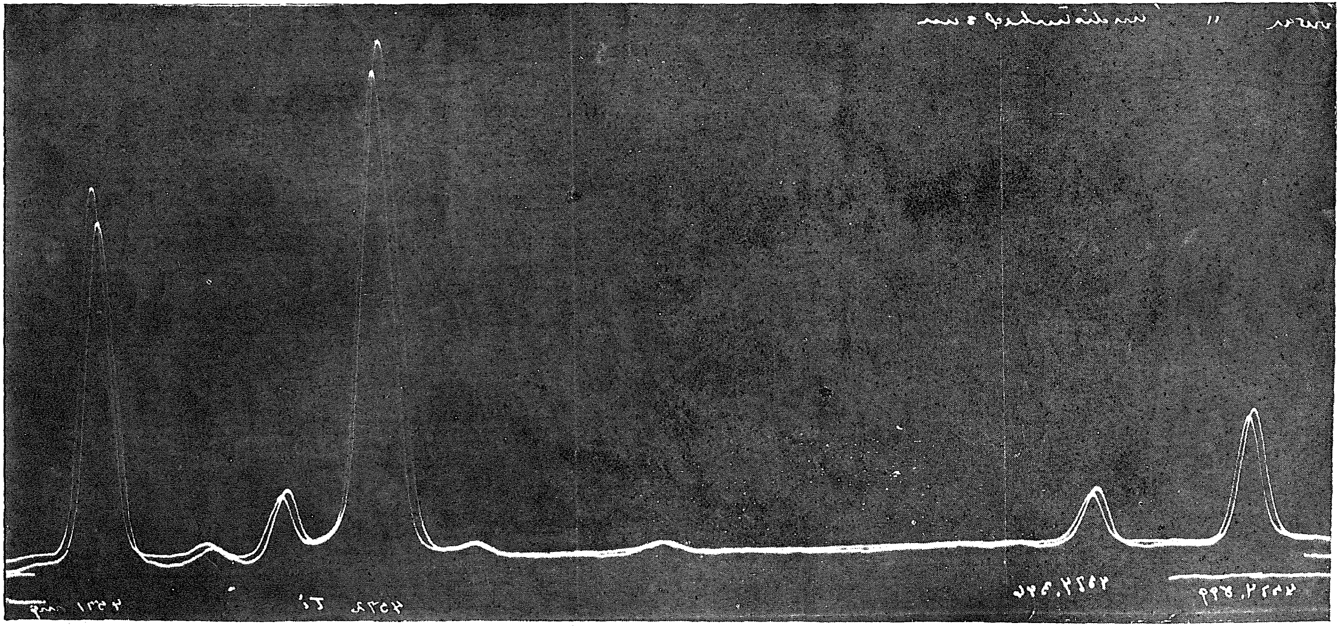
Just as spots are regions of local cooling, the faculae are regions where the temperature has been increased over that of the general photosphere. Hence it was predicted that the spectrum of the faculae would be similar to that of *F*-class of stars. This prediction has been verified by Dr. St. John of the Mount Wilson Solar Observatory who took simultaneous photographs of the spectra of the sun and the faculae, and found that the lines of Ti^{+} were considerably enhanced in the faculae.

CONDUCTIVITY OF FLAMES.

Recently, the ionisation theory has received confirmation from an unexpected quarter. It is well-known that a Bunsen flame becomes conducting when sprinkled with metallic salts. Very careful experiments on the subject were carried out by Gold and H. A. Wilson, who found that the conductivity was highest in the case of the alkali elements, and in fact in the order *Cs*, *Rb*, *K*, *Na*, *Li*. After the ionisation theory was published, Noyes and Wilson undertook a re-examination of the whole data, and found that they could be explained on the supposition that the metals were ionised at the temperature of the flame, according to equation (2), and the conductivity was wholly due to the free electrons arising out of the ionisation of the atoms. In fact the agreement was so good, that according to Noyes and Wilson, the ionisation potential could be calculated in the reverse way from the conductivity of flames when sprinkled with metallic salts.

EXPERIMENTAL VERIFICATION.

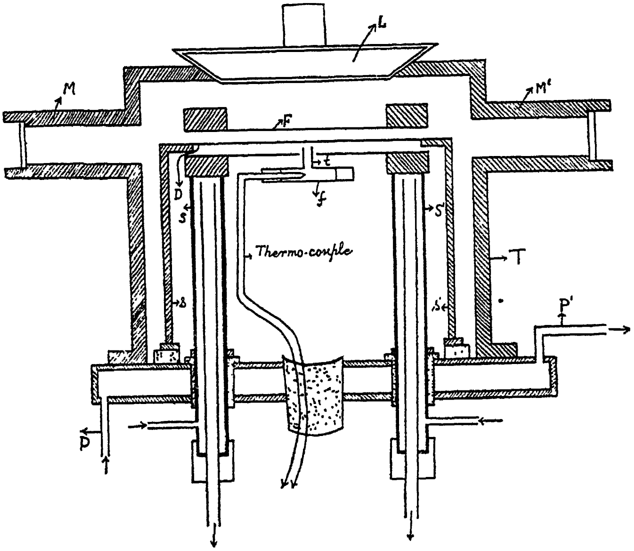
According to the ionisation theory, all atoms would be split up, at high temperatures into electrons and a positive residue.



[Microspectrophotogram of a portion of the solar and facular spectrum in the region λ4400, containing enhanced lines of Ti. Note that the intensity (represented by the ordinate) of Ti$^+$lines increases in the facula. From a copy kindly presented to the author by Dr. St John.]

At low temperatures the gas would be electrically neutral, i.e. it would not conduct electricity at all. But at high temperatures owing to the presence of free electrons, a considerable amount of electrical conductivity may be expected.

When the ionisation theory was first propounded there was no experiment to verify this deduction from the theory though indeed a large number of experiments to observe this effect had previously been done by J. J. Thomson and Mac Lennan on mercury vapour, with entirely inconclusive results. Now mercury has an ionisation potential of 10·45 volts, and calculation shows that a temperature of at least 6000°K is required to produce appreciable ionisation. Such a temperature cannot be realised in the laboratory, and we have to fall back upon a substance for which the ionisation potential is very low. Analysis of series spectra shows that the alkali elements, particularly Cs, have the lowest ionisation potentials, but experiments with them are naturally more difficult to perform.



[The apparatus consists of a vacuum furnace F enclosed within an iron chamber M which is closed by quartz windows. The furnace is heated to temperatures of 2500° by electric current. The element is kept in the smaller furnace *f* which, when heated, yields vapour in F. Electrical conductivity of the vapour space in F is measured between the surface of F and a centrally mounted wire by the ammeter voltmeter method.]

Some preliminary experiments at Prof. Nernst's laboratory at Berlin on alkali vapours confirmed these predictions.

Recently a more elaborate series of experiments in collaboration with Mr. N. K. Sur of the Ewing Christian College, Allahabad, have been undertaken in my laboratory at Allahabad. The apparatus is shown in the adjoining figure. Experiments were undertaken with *Na*, *Ca*, *Sr*, *Mg*, and Zn, and the results, though preliminary, were found to be in complete accord with the ionisation theory.

IONISATION IN A MIXTURE OF GASES.

As remarked above, ionisation in a mixture of gases is given by Russell's equation

$$\log \frac{x}{1-x} \cdot \frac{f}{1+f} = \frac{U}{-2{\cdot}3RT} + \frac{5}{2} \log T - 6{\cdot}5$$

where f = concentration of electrons, is arbitrary. Russell applied this equation to a discussion of the difference between the spectra of spots and of the photosphere. He found that as a rule the spark lines of all elements (particularly of the alkaline earths) are weakened in the spot, while the arc lines are greatly strengthened. The discussion was also extended to *Ti*, *Fe*, *Zn*, and *V*.

Russell drew another very important conclusion from equation (B). If we start with *Ca* alone and continue heating it, then at a certain temperature a definite equilibrium will be reached between *Ca*, Ca^{+}, and electrons. If we now add some other substance like potassium which becomes ionised more readily, the stimulus will, by preference, pass through the more easily ionisable atom, and the proportion of *Ca* atoms will become less, the enhanced lines *H* and *K* will become greatly weakened. The experiment was actually performed by Dr. A. S. King in his tube furnace. A temperature of 1800°C was chosen, and with *Ca* alone in the tube, the lines *H* and *K* were obtained in absorption. A small quantity of potassium was then introduced. The *H* and *K* now completely disappeared, while the *g*-line remained entirely unaffected. This also explains the phenomenon recorded by Paschen that if an element under some condition of excitement gives a spectrum in which neutral lines and enhanced lines are freely mixed together, the enhanced lines can be almost entirely suppressed if the element is mixed up with some more easily excitable element.

LUMINOSITY OF HEATED VAPOURS.

The ionisation theory also puts an end to the long-standing controversy whether gases can be made luminous by heat alone. A large number of experiments was done by Pingsheim and others, and they concluded that at least up to 2000°C it is not possible to excite permanent gases like H, He, Ne, A, O, and N, to luminescence by heat alone. On the other hand, King had shown that the alkalies, the alkaline earths, thallium, Fe, Ni, Co, and many other elements can be made to give out their line spectrum in his tube furnace, where temperatures varying from 1800°C to 3000°C are produced by passing electric current through a graphite tube in vacuum. King took spectra at different temperatures, and showed that different classes of lines are emitted at different temperatures.

Many investigators like Hemsalech and others tried to interpret these results as purely electrical phenomena, but King stoutly defended his point, and showed that the lines persisted even when the current was cut off, as long as the temperature did not fall very low.

According to the conceptions presented above, the standpoint taken by King was undoubtedly right, though as a result of Bohr's theory, the controversy electrical stimulus *versus* thermal stimulus is seen to be without any significance. According to Bohr's theory, the line radiation of an element is due to the jump of the electron from a meta-stable to a more stable orbit, and hence luminiscence depends entirely upon the transference of the electron to the higher state. This can be produced by electrical discharge as well by heat, if the temperature is sufficiently high. Thus as mentioned above, if we start with calcium, the products of reaction at high temperature are not only Ca^+ and e, but calcium atoms in excited states, and these give rise to the arc spectrum of calcium. The temperature required for luminiscence will depend upon the excitation potential of the line, i.e. upon the difference in the energy between the metastable state to which the line belongs and the normal state.

Now in the case of metals studied by King, the excitation potentials are rather low; hence the spectrum was obtained even at as low temperatures as 2000°C. But Pringsheim, on the other hand, chose elements of which the excitation potentials for visible lines are very high. Thus to produce the $H\alpha$-line of the hydrogen we require at least 13·6 volts; the D_3 line of helium requires at least 21 volts. Such large stimulii cannot be produced even at the highest temperatures available in a laboratory. In the case of helium, in fact, we know from stellar data that they do not occur earlier than at B class of stars, and temperature here cannot be less than 12000°C.

King's data on the classification of lines on a temperature basis are thus a valuable guide to a knowledge of the excitation potential of the element in question, and in recent years, they have been used with great advantage by Catalan, Laporte, Meggers, Kiess, Walters and others for the classification of line-spectra of elements of higher groups. But the exact law of the production of these orbits at higher temperatures has yet to be worked out.

SUBATOMIC THERMODYNAMICS.

The considerations presented in the previous pages foreshadow an extension in the "Thermodynamics" which may be fitly styled as "Subatomic Themodynamics." It will deal with the physical processes which occur when atoms are split up by heat into electrons and positive residues. At present, the application is confined to stellar bodies, but it is expected that in future, more experiments bearing on the subject will be carried out in the laboratory. The theoretical progress in the subject will naturally go hand in hand with our knowledge of the structure of the atom, and with physical study of radiation which, according to Bohr's theory, is simply a byeproduct of the changes in the position of the component electrons. But much will depend on the introduction of new and more powerful methods in thermodynamics, and works in this direction are already appearing.

NEW METHODS IN THERMODYNAMICS.

Before dealing with these new works on subatomic thermodynamics, we shall give a short sketch of the more recent methods in thermodynamics, which have made it possible to start with a working theory of thermal radiation and ionisation of gases. It was Boltzmann who first cleared up the nature of the mysterious and elusive function 'Entropy,' and established the first link between thermodynamics and statistics. As is well known, according to Boltzmann, S (Entropy) $= k \log W$, where W denotes the probability of a statistical system. Boltzmann dealt with only comparative values of the probability, but Planck showed that it was possible to assign an integral and absolute value to the probability of every thermodynamical system. Following a method given by Gibbs, he calculated the value of absolute probability for a perfect gas, and for perfectly black radiation. It was in this latter connection, that he was led to the introduction of the famous universal constant 'h' bearing his name. Planck recognised very early that $h = \iint dp \, . \, dq$, where p and q are the momental and positional co-ordinate of each unit in a thermodynamical system for each of its degrees of freedom. Sackur and Tetrode simultaneously calculated the absolute value of entropy of a perfect monatomic gas by using the theorem that $h = \iint dp \, . \, dq$. It was in this connection that Sackur deduced the correct value of the chemical constant for a monatomic gas (viz. $C = -1 \cdot 62 + \frac{3}{2} \log M$). The idea of chemical constant we owe to Nernst, and it is superfluous to add what a great part it has played not only in the study of chemical equilibria, but also in the development of the theory of thermal ionisation of gases.

A few years ago, (1920), Professor Ehrenfest of Leiden undertook a re-examination of the fundamental points of Planck's thermodynamics, and showed that problems of dissociation equilibrium are best dealt with by the introduction of a function $\{\gamma\}$, which may be defined as the total phase space described by the system, when it is built up from the elementary units. Ehrenfest's method has been very largely followed by recent workers on thermal ionisation of gases, particularly by Fowler and Milne, by Becker, and by the present writer and R. K. Sur. The present writer and R. K. Sur, have shown that Planck's W and Ehrenfest's $\{\gamma\}$ are connected by a very simple relation, and there is essentially not much difference between the two methods. Ehrenfest's method, it may be mentioned, is equally applicable to matter as well as to radiation.

FOWLER AND MILNE'S WORK.

The essential points in Fowler and Milne's work will be realised from the following brief summary :—As mentioned above when an original mass of Ca is heated, the products of decomposition are not only Ca^+, e, but also Ca-atoms in the excited states, which, being unstable, are giving rise to the line spectrum of Ca. As the spectrum of Ca is rather complicated we shall take a simpler case viz. H. The products of decomposition are then H^+, e, H-atoms in 1_1, 2_2, 2_1, 3_3, 3_2, 3_1.... states, radiation

$$\nu = N\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$$

constituting the Lyman Series, the lines

$$\nu = N\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$

constituting the Balmer series etc.... In the simple theory sketched above, we neglected these intermediate orbits which is justified on the ground that even at the highest temperatures, their proportion, calculated according to Maxwell's theorem, is negligible.

By applying Ehrenfest's method, (which has been improved on mathematical points), R. H. Fowler obtains the equation :

$$log\ \frac{x^2}{1-x^2}\,P = K - b\ (T)$$

in place of the original equation. The function $b\ (T)$ represents the occurrence of intermediate orbits

$$b\ (T) = g_0 + g_1\,e^{-\frac{u_1}{RT}} + g_2\,e^{-\frac{u_2}{RT}} + \dots$$

where g_0, g_1, g_2 . . . are the intrinsic weights, of the normal state, and the excited states having the total quantum numbers 2, 3 . . . . . u_1, u_2 represent the energy of excitation of these states.

For the hydrogen atom, $u_n = Nh\left(1-\frac{1}{n^2}\right)$, according to Bohr, and $g_n = n\ (n+1)$ according to Herzfeld and Epstein.

Fowler and Milne have drawn very interesting conclusions from this equation, but before giving an account of their work, it ought to be mentioned that $b\ (T)$ is divergent. This is due to the fact that g_n has been taken to be proportional to the number of orbits possible having the total quantum number n. The procedure seems to be unsound on physical grounds. Fowler is of opinion that the difficulty can be avoided by cutting the series at some finite term. He justifies the procedure on the following ground :—The radius or the major axis of the *n-th* orbit is $a_0\, n^2$, and hence at a finite pressure, when n is sufficiently large, the vibrating electron may run to such a distance from the nucleus, that it passes under the influence of other nucleii as well, it passes, so to speak, into No-man's land. As was pointed out in a recent note to Nature, there must therefore be a limit to the number of orbits developed, a limit depending on pressure.

The above speculations are confirmed by the experiments of Wood who has shown that higher Balmer lines are produced only when the pressure in the discharge tube is very low, and also from the number of Balmer lines occurring in stars having varying pressure in the reversing layer. But these considerations by no means justify the assumption $g_n = n\ (n+1)$.

The conclusions reached by Fowler and Milne are however largely independent of the particular value which may be assigned to g_n, and depend on the occurrence of the factor $e^{-U_n/KT}$ in $b\ (T)$. It will be recalled that many elements in the Sun and the stars have to be identified by subordinate lines. e.g. Mg which is identified by the *b*-lines, $2\ p-ms$, or Mg^+ which is represented by $\lambda 4481$, $3d-mf$. Fowler and Milne discovered that there is a very remarkable difference in the behaviour of the principal lines and subordinate lines of known elements in the stellar sequence. The principal lines are most intense at the lowest temperatures and gradually die out with increase of temperature. The subordinate lines are at first very faint, gradually rise to a maximum and then again fall off to zero.

Fowler and Milne explain the phenomena on the following grounds :—At the lowest temperatures, all atoms are in the normal state; there are none in the higher states. With increase of temperatures, the higher states begin to come out. When the temperature is still further increased, the atoms begin to get ionised, and hence the proportion of atoms in the subordinate series begins to fall off. A maximum must have been reached in the interval.

When the above ideas are translated into mathematical language, and conditions for maximum concentration of subordinate levels applied, we get a relation connecting the electron pressure in the reversing layer and this temperature:

In fact

$$P_e \text{ (electron pressure)} = \frac{\cdot 332}{b\,(T)} \frac{u_r + \frac{5}{2}RT}{u_1 - u_r} T^{\frac{5}{2}} e^{-\frac{u_1}{RT}} \qquad (D)$$

For example, the Balmer lines of hydrogen arise from the 2_2 orbit, and they reach their maximum in the A-class. The temperatures of these stars lie between 10,000°K and 12,000°K, substituting these values in (D), we obtain

$$P_e = 1{\cdot}31 \times 10^{-4} \text{ to } 3{\cdot}07 \times 10^{-3} \text{ atmospheres.}$$

Fowler and Milne have thus found a very elegant method of determining the pressure. This is in itself a result of the first magnitude, for ionisation depends very largely upon pressure, and after Einstein's discovery of the shift of the lines by gravitational potential, the older values which were based on pressure-shift of the lines have been rendered obsolete.

Values of P_e have been calculated from considerations of the maxima of several elements, and they invariably give a range of pressure varying from 10^{-3} to 10^{-5} atmospheres. These values recall the statement of Jewell that "the whole mass in the reversing layer of the sun can be contained in a thimble."

IONISATION OF ELEMENTS OF HIGHER GROUPS.

Elements of higher groups, like C and Si, having two or more electrons in the outer ring show multiple stages of ionisation in the stellar range. Thus we get lines of Si, Si^{+}, Si^{++}, Si^{+++} in the stellar range. In the case of ionised elements, principal as well as subordinate lines would show maxima owing to the commencement of the next stage in ionisation. But a scrutiny of stellar data in these cases shows that the ionisation potential is not the only factor in determining ionisation. Thus *Ba* and *Na* have the same I.P viz 5·1 volts, but *Ba* is completely ionised in the sun, while *Na* is at best only 60 or 70% ionised. For elements with higher valency, i.e., with more electrons in the outer ring, the effect is much more pronounced.

The matter is very closely connected with the structure of the atom, and the nature of its spectrum. A comparison belween *Na* and *Ca* will bring out the point clearly. Sodium has only one electron in the outer ring, the electrons in the inner ring being very tightly coupled to the core. This is shown from the fact that the first 1.P. of *Na* is 5·1 volts, the second

I.P. is not less than 35 volts (Bureau of Standards measurements). When a stimulus falls on *Na*, the whole shock falls on the outer electron. Besides *Na* has got a very pronounced principal series, the leading members of which, the D_1 and D_2, completely dominate the spectrum. In other words, ionisation can take place only in one way, by passage from *Is* (normal) through $2p$-stages.

Calcium has two electrons in the outer ring and both of them are rather loosely attached, for the first I.P is 6·1 volts, the second about 13 volts. Hence when any stimulus falls on *Ca*, both electrons may sometimes be simultaneously excited. The reality of simultaneous excitation of two electrons has been established by Russell and Saunders and Wentzel who have recently shown that a strong group of arc lines owe their existence to such a process.

Generalising we may say that for alkalies and for elements which acquire an alkali-like structure by loss of electrons (say Ca^{+}, Al^{++} . . .) the stimulus can excite only the outermost electron, and most of it is spent in disturbing the normal level. For elements with two or more outer electons, the stimulus can sometimes excite, more than one electron at the same time and the stimulus is distributed amongst a number of levels.

Recent work on the analysis of spectra of elements of higher groups shows that the terms normal level, and principal level, lose, in these cases, much of their significance. There are always a number of close lying normal levels, and the stimulus is distributed amongst them.

While the nature of the phenomena is well understood, it is very difficult to translate these ideas into a thermodynamical theory. Meanwhile all attempts to frame a rigorous theory of ionisation and radiation for higher elements must be of an *ad hoc* nature, pending a fuller knowledge of their spectra, and of the intrinsic weights of the different orbits.

KINETIC METHOD.

Prof. Milne has recently given an entirely new method of dealing with thermal ionisation of gases. In contradiction to the thermodynamical method hitherto used, this method may be called the kinetic method. These two method find their parallel even in the study of chemical equilibria. Let us represent a typical homogeneous equilibrium by the equation

$$mA + nB \rightleftarrows pC + qD.$$

Then according to the thermodynamical method (mA denoting m-atoms of type A) we put

$$mS_A + nS_B - pS_C - qS_D = -\frac{U}{T}$$

where S's are the entropies, and U is the heat of reaction.

In the kinetic method, the rate of change from left to right depends on the number of times m molecules of A come into contact with n molecules of B. The velocity of reaction

$$V_{AB}=K_1\, C_A^m\, C_B^n,$$

and $$V_{CD}=K_2\, C_C^p\, C_D^q,\ \mathrm{C}=\text{concentration}.$$

In the equilibrium case

$$V_{AB}=V_{CD} \text{ or } \frac{C_A^m\, C_B^n}{C_C^p\, C_D^q}=\frac{K_2}{K_1}=\text{a constant}$$

By using this method, Boltzmann deduced a formula for molecular dissociation which has the same form as the formula derived from thermodynamics.

Thermal ionisation of gases is only a particular form of chemical dissociation with the difference that the details of the mechanism are much better understood in the former case. Hence, it is expected that the kinetic method would be fruitful here, but a detailed treatment of the reaction is necessary.

THE UNIT MECHANISM AND PRINCIPLE OF DETAILED BALANCING.

Every kinetic method depends on a closer treatment of the mechanism of reaction. The reaction in the present case is the decomposition of M into M^+ and e, and this can take place in a variety of ways. To any one of these processes, there must be an opposite process resulting in recombination of M^+ and e to M. A pair of such oppositely directed processes has been called by R. H. Fowler "Unit Mechanism." Each one of these mechanisms, by themselves and without the aid of any other process, would give us some fundamental laws of general validity. This is known "As the principle of detailed balancing."

The ionisation of M-atoms placed in a thermal enclosure can occur:

(*a*) As a result of collision of two M-atoms (ionisation by collision)—the rate of ionisation is then proportional to the square of the pressure.

(*b*) As a result of absorption of radiation by H-atoms, normal as well as excited (photo electric ionisation).

Thus, according to Bohr's theory, radiation of frequency greater than $\frac{N}{1^2}$, when falling on a normal H-atom would completely ionise it. If the electron is in the 2-state, radiation shorter than $\nu=\frac{N}{2^2}$ would ionise the atom. This is true of every element, and in the case of alkalies it has been definitely proved that these vapours are ionised by radiation shorter than that corresponding to the limit of the principal series. The reverse process of capture when M and e come together must also be radiationless. Hence when M^+ and e combine together, the energy set free must be carried away by a third body. Hence the reverse process to (a) is a three body encounter between M^+, e, and M (or e), the energy liberated being carried off by M. The unit mechanism (a), (a') has been studied by R H. Fowler in an extension of the ideas of Klein and Rosseland on the so called collisions of the second type.

(b) The reverse process to (b') must naturally be the capture of an electron by the ion M, with liberation of radiant energy. But Milne finds that (b) and (b') together do not give the law of reaction isochore. So he postulates that electrons may be captured even under the influence of radiation. This last process is analogous to Einstein's "Negative Einstrahlung" or stimulated emission. Thus we may write

Rate of photoelectric ionisation = Rate of capture with emission of radiation + Rate of capture under the influence of radiation.

Compare it with Einstein's well-known method of deducing the law of black body radiation.

Rate of absorption of light = Rate of spontaneous emission + Rate of emission under the influence of the field of radiation.

With the aid of certain assumptions, Milne calculates the rates of free and stimulated captures and equates it to the number of photoelectric ejections. The equation may be used in two ways. It may be employed to evaluate the degree of ionisation, in which case some further assumptions are necessary. Conversely, assuming the thermodynamic formula for ionisation, it can be used for finding out the law of probability of electron capture. In this way Milne arrives at the conclusion previously arrived at by Eddington in his study of opacity of stars, namely the electron is captured, only when it actually hits the nucleus. Probably a more rational way of expressing the result will be that only one in 10^5 collisions result in a capture.

Applied to H, Ca, and Hg, Milne's method furnishes values of absorption cœfficients which are in general agreément with experimental values.

It is yet too early to predict how far Milne's method in its presents form will be able to advance the theory of thermal ionisation. The great difficulty which is encountered in the development of these methods is due to the absence of any suitable quantum theory of absorption of lines. The present theories are a sort of half-hearted compromises, with the the old Lorentz theory which ascribes absorption to damping produced by collision.

INFLUENCE OF RADIATION ON IONISATION EQUILIBRIUM.

The formulæ for ionisation which have been given above yet suffer from another defect. We have been making the tacit assumption that the radiation is in equilibrium with matter at the temperature concerned. While this assumption is quite true when we heat the metal in a closed space, or in the interior of stars, it is evident that in many cases, the assumption is far from the actual truth. We take the following typical examples :—

(1) When continuous radiation is allowed to pass through a mass of sodium vapour as in Wood's absorption experiments. Here the vapour may be at a temperature of 500–600°C, while the radiation, if it comes from the arc, is at a temperature of 4000°K.

It may be pointed out that all photo-chemical reactions—such as the ozonisation of oxygen by ultraviolet light, etc.—belong to this class. Only in this case, the mechanism of the reaction is not quite so clear as in the case of sodium absorption.

(2) The chromospheric phenomena,

The chromosphere is at a much lower temperature than the photosphere (say 5000°K to 6500°K). Hence the radiation from the photosphere which is pouring through chromospheric gases is at a higher temperature, as was first pointed out by Milne.

In this case, we cannot speak of thermodynamic equilibrium in the strict sense, but there is a sort of dynamical equilibrium.

(3) The phenomena in the Novæ and O-type of stars.

There are reasons to believe that in many stars, particularly in Novae and those with a dense atmosphere, the region from which the continuous radiation comes, and the outer envelope where the absorption takes place are at different and varying temperatures, sometimes the one, sometimes the other temperature becoming higher.

In all these cases, the reacting radiation is to be regarded as a new component. The equilibrium condition can be easily deduced by slightly modifying Sackur's equation.

Then the law of ionisation takes the form

$$log\,\frac{x^2}{1-x^2}P = -\frac{U-Nh\nu)}{RT} + log\,\frac{\rho\nu}{\frac{8\,\pi h\nu^3}{C^3}+\rho\nu} + \frac{5}{2}\,log\,T - 6{\cdot}5$$

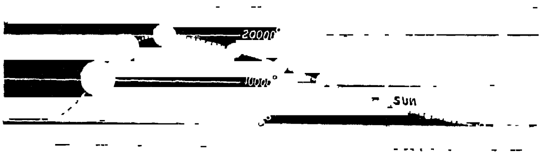
ρ_ν = density of radiation

When the radiation is due to the temperature of the system, i.e., there is thermodynamic equilibrium, the equation reduces to the form 1).

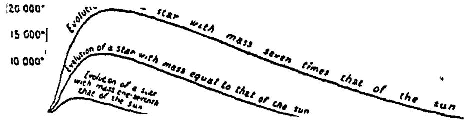
This is the general form of a formula given by Einstein in 1911 for photo chemical reaction.

EDDINGTON'S THEORY OF STELLAR EVOLUTION.

Mention of Einstein reminds me of the important lesson he has taught us, viz. that both space and time are limited. I believe that many of you would like to remind me of this lesson. I would however crave your indulgence in extending for my benefit both the time and the space-limit. From what has been said you will see that in subatomic thermodynamics we have a combination of the methods of physical chemistry, the quantum theory, and of theories of atomic structure. If offers vast possibilities of work, experimental, theoretical, as well as observational. It is already engaging the attention of a large number of workers in Europe, and America, and very fine results are being achieved. I have given a very brief account of these works. In the present address I have dealt chiefly with stellar atmospheres, in which the temperature varies from 3000°C to 50000°C. But Eddington has taken us deep into the interior of stars, where temperatures of the order of billion degrees prevail. He has dealt with the large question of the life history of stars, which is inseparable from the present theme. He starts by considering a mass of extremely rarefied dark matter, which gradually goes on contracting owing to the mutual gravitation of its part. A stage is reached when the interior becomes ex-



(Diagrammatic rcpresentation of the theoretical development of a massive star from an original nebula to a final cold, dense body.)



(Curves illustrating the course of evolution of stars of differing mass, showing that, the more massive the star, the longer is its life and the greater is the range of temperature through which it passes. Both diagrams are taken from an article by Prof. H. Dingle in Nature.)

ceedingly hot, and begins to radiate. Radiation as it flows through the outer envelope of matter exerts pressure on them. A considerable fraction of gravity is counterbalanced by the pressure of the escaping radiation. This causes the rate of evolution to slow down and a consideration of the relations between the total mass, density, and effective temperature shows that the limit of evolution is reached at a certain stage depending upon the total initial mass. Thus a mass having the same quantity of matter as our Sun can at best reach the *F*-Stage (surface temperature-9000°C), while a star like Sirius having 4 times the solar mass, may reach the *B*-stage (having the surface temperature of 20000°C). Once the maximum stage is reached, the star will begin its downward career, i.e., the loss of energy by radiation will be larger than the evolution of energy due to contraction. The star will become cooler and cooler until it dies a natural death, as is the case with the moon.

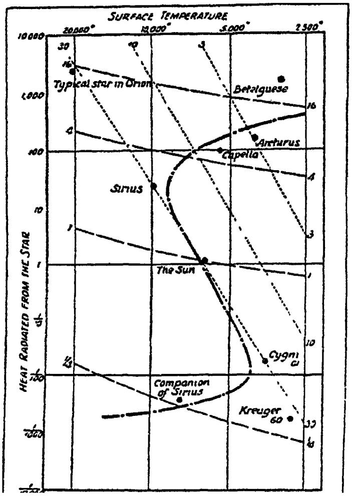
According to Eddington, a star will have the same surface temperature twice in its life career; (first) when it is rising in temperature; at this stage the density is very low and the star will therefore have a very large surface. This is known as the giant stage; secondly, when it is falling in temperature; the star had reached the maximum contraction and hence its density is very large, and total luminous surface is very small. This is known as the dwarf stage. Eddington's theory explains in a very clear way Lockyer's hypothesis of ascending and descending stages, which was subsequently amplified and put on a firmer basis by the researches of Russell and Hertzsprung.

I have not the time to speak of the many triumphs of Eddington's theory, but one spectacular triumph must not be omitted, and is probably known to many of you. The bright red stars are all giants, and have an extensive surface. Eddington predicted from his theory that the bright star α-Orionis (Betelgeuze) would have a diameter of $3{\cdot}4 \times 10^8$ Kms. with a parallax of ·045″. This was brilliantly confirmed in 1921, when Pease and Anderson of the Mount Wilson Solar Observatory, by an application of Michelson's interferometric method measured the actual diameter of the star and found it to be closely agreeing with the values predicted by Eddington, and by H. N. Russell.

SOURCES OF STELLAR ENERGY.

But the puzzling question of "Sources of Stellar Energy" still defies all attempts at solution. Throughout its trillion years of existence, a star must be radiating enormous amounts of energy. The question now rises 'where does all this energy come from?' It was first raised in connection with the sun. The sun is radiating 5×10^{27} calories of heat every minute, and unless this loss is replenished by some other source, it would become extinct in a few thousand years. Helmholtz showed that if we assume that the sun is contracting by 28 yards every year, the energy obtained from this contraction would suffice to restore the loss. But the actual time scale is infinitely large compared to the rate of evolution of heat obtained from gravitational contraction.

Dealing with the larger question of the source of energy in stellar masses, attempts have been made to show that evolution of heat by radioactive emission or some other subatomic source of energy might be the long-sought-for source. The inside of a star must be highly ionised, and further contraction would result in the recombination of the free electron with the positive residue. This would liberate a certain amount of energy, as in the recombination of Ca^+ and e to form Ca, $1{\cdot}40 \times 10^5$ calories of heat are evolved. But Russell, as well as Nernst in his 'Werden der Welte' finds that this source is also insufficient to account for the observed time scale. Attempts have been made to show that the radiated energy may be retransformed into matter, according to the Einsteinian law $m = \frac{E}{c^2}$ but this does not seem to be more than a vague suggestion.



THE "S" CURVE OF THE MODIFIED THEORY

[Modified form of the Theory of Giant and Dwarf stars according to H. N. Russell. In this scheme, Super Dwarfs (e.g. companion of Sirius), as well as Super Giants (c—stars) have a place.]

WHITE DWARFS—COMPANION OF SIRIUS.

At the present time, all speculations have been thrown into disorder by the discovery of "white dwarfs" and on account of the importance of this discovery, I would dwell at some length on its probable significance. Sirius which is the brightest star in the heavens, has got a companion 10^{-4} times fainter than itself which was discovered in 1845 by Alvan Clark. From calculations of the orbit, the mass was found to be 1/4 of Sirius, i.e. about 3/4 of the sun. In spite of its large mass, the star is extremely faint, and hence either the temperature must be very low or the surface very small. But the star is almost white and the spectrum is of the early *F*-type. Hence the surface must be extremely small, and actual calculation shows that the diameter cannot be larger than that of Uranus.

In the companion of Sirius, we have therefore a star with 3/4 the mass of the sun, but with a diameter which is about $\frac{1}{30}$ of the solar diameter, and a surface temperature of about 9000°C. The density reaches the enormous value of 50,000 while the density of the solar mass is only 1·31. The gravitational potential is 32 times the gravitational potential on the sun. Hence it was pointed out by Böttlinger that the star was very suitable for testing the Einstein prediction of shift of lines towards the red. On the Companion of Sirius, a line of wave length 5,000A° would be shifted by about ·3A° units, while the shift on the sun is only ·013 units. Actual measurement of spectrograms of the companion of Sirius taken by Adams in the Mount Wilson Solar Observatory shows, that the absorption lines on the spectra of this star are actually shifted by this amount. This is a brilliant confirmation of Einstein's theory of Relativity and probably removes the last shade of doubt about the validity of that theory. But the discovery is of far greater consequence to theories of evolution, for matter is compressed in this star to a density which is about 2,000 times the density of the heaviest metal known on earth. A few years ago, such a fact would have presented insurmountable difficulty, but thanks to the development of the atomic theories, the case does not appear so hopeless now. It is apparent that the star consists only of stripped atoms, that is to say of atoms which have lost some of their outer rings of electrons. This must be due to the high temperature prevailing in the star, but it is not at all clear how stripped atoms with a large excess of positive electricity can be so closely packed; because as the charges are of the same sign, the tendency would be for infinite dispersion, instead of abnormal condensation. But such cases of abnormal condensation are not altogether unknown in Physics. The nucleus of atoms consist of a large excess of positive charges which are somehow packed within a very, very small compass. The forces which hold together the positive charges, in spite of their mutual electrical repulsion, must be of a nature which is yet undreamt of in any theory of physics. An analysis of stellar data shows that such forces are developed when the central temperature exceeds a certain value. In the case of a heavy element like Uranium the first ring of electrons, and outer periphery of the nucleus are almost coterminous, and Jeans shows from stellar data that in such atoms, the intra-atomic energy cannot arise solely from electrical forces. It is not improbable that the stripped atoms within a white dwarf are so much compressed that the nucleus becomes coterminous with the outer rings, and the forces surmised by Jeans come into operation even in the case of lighter atoms.

CONCLUSION.

Gentlemen, I feel I have taken too much of your time, and further continuation of the theme would be torture to you. It is certainly very flattering to find that the number of papers in this section has exceeded a hundred, and contributions have been received from all parts of India. It signifies that a creative impulse has come amongst the teachers of our subject, and this is replacing the old habit of pedantry and stage acting. It is generally thought that the importance of regarding creative work as the noblest ideal for a teacher was never recognised in this country and that this idea has been a recent import from Europe. This is at best a half truth for otherwise, we could never have such positive sciences as medicine, astronomy and mathematics. My revered teacher Prof. Sir P. C. Roy, has unearthed for us the following remarkable passage from a writer of the ninth century [Dhundukanath in Rasendra-Chintamāni] :—

अश्रौषं बहुविदुषां मुखादपश्यम्
शास्त्रेषु स्थितमकृतं न तल्लिखामि ।
यत् कर्म.व्यरचयमग्रतो गुरूणां
प्रौढानां तदिह वदामि वीतशङ्कः ॥
अध्यापयन्ति यदि दर्शयितुं क्षमन्ते
सूतेन्द्र कर्मगुरवे । गुरवस्त एव ।
शिष्यास्त एव वचयन्ति गुरोः पुरे ये ।
शेषाः पुनस्तदुभयाभिनयं भजन्ते ॥

"I have heard much from the lips of savants, I have seen many (formulæ) well established in Scriptures, but I am not recording any which I have not done myself.

I am only recording those fearlessly which I have carried out before my elders with my own hand. They are alone to be regarded as real teachers who can show by experiments what they teach. They are the deserving pupils, who, having learnt from their teachers can actually perform them, and (improve upon them). The rest are merely stage-actors."

Unfortunately for India, this high ideal was wrecked by pedants—men who regarded worship of ancient scriptures as the highest ideal of scholarship. Europe was also drifting into the same mess, her scholars at one time used to regard the worship of the Bible, Plato and Aristotle as the highest consummation of scholarship. But she was rescued out of the abyss into which she was drifting by the life-blood of Galileo, Bruno and Kepler. Unfortunately India had no martyrs of the above type for Science. But recently examples have been forthcoming which show that the Indian brain is quite capable in the matter of creative scientific work. Encouraged by these examples, teachers are now taking in large number to creative work, and the Sadler commission has wisely set a legal stamp on such works.

The Sadler Commission has recommended the organisation of the teaching profession on a basis, which, if loyally adhered to, will foster the spirit of research and scholarship. But though many universities have been remodelled on the basis of these recommendations, the menace from pedants and stage actors has not entirely disappeared. Another menace is the want of encouragement and dearth of facilities for research work. It is our experience that with the transfer of education to popular control, and consequent reorganisation of university education, the whole machinery has become so complex that it is next to impossible to get any extra money for research work. The researcher who wants more money for his work is not infrequently treated like Oliver Twist in the Charity House "he has asked for more!" Even in medieval and ancient times, it was considered a duty on the part of the State to help the seekers after truth. I am thankful to the learned Vice-Chancellor of our University for the following remarkable passage in the writings of Rajsekhar, the Court poet of King Mahendrapal of Kanauj: who lived in the ninth century A.D.

महानगरेषु च काव्यशास्त्रपरीक्षार्थं ब्रह्मसभा कारयेत्। तत्र परीक्षोत्तीर्णानां ब्रह्मरथप्रयानं पट्टवन्धश्च।

"In big cities, assemblies of learned men (Brahmasabha's) should be held under the patronage of the king for examining poetical and scientific works. And the successful should be conveyed in a special chariot (Brahmaratha) and should be crowned with a fillet."

Well, if the medieval states could be so solicitous for the encouragement of the seeker after truth, he has surely a claim on the modern civilized state.

Regarding the theme of this address, I may conclude in the words of Prof. Henry Norris Russell:—

"The possibilities of the new method (method of subatomic thermodynamics) appear to be very great. To utilize it fully, years of work will be required to study the behaviour of the elements mentioned above and of others, in the stars, in laboratory spectra, and by the direct measurement of ionization, but the prospect of increase of our knowledge, both of atoms and of stars, as a result of such researches, makes it urgently desirable that they should be carried out."

Abstracts of Papers.

1. On the possibility of existence of the Sub-electron.—*By* S. N. Roy.

The existence of the sub-electron is rendered possible by the experiments of Ehrenhaft and his students. The author discusses the problem from various standpoints and also from his own experimental work, and comes to the conclusion that charges less than the electronic charge do actually occur in Nature.

2. On the constitution of the electrified particle from the generalised principle of Relativity.—*By* N. R. Sen.

It has long been recognised that the total energy of the electron cannot be wholly Maxwellian, for the electron would explode on account of the mutual repulsion of the parts of the charge. Poincare suggested the existence of a surface pressure which would prevent this explosion, and this has been looked upon as providing for the non-Maxwellian source of energy. The microscopic equations of Einstein designed to formulate a theory of the constitution of the ultimate material particle, though found satisfactory in some directions, fail, however, completely to account for the existence of the electron; but they suggest that a part of the total energy of the ultimate particle must arise from gravitational sources. If now we assume a volume distribution of charge inside an electrified particle of definite radius, which agreeing with Einstein we take to be held together by gravitational forces, the following interesting results can be obtained. There is a continuous distribution of force inside the electrified particle arising from the gravitational field which keeps the particle in equilibrium. This force is of the nature of hydrostatic pressure which just vanishes on the surface of the particle. The total Maxwellian energy inside and outside the particle is found to be three times the total gravitational energy binding the same. This would suggest that three-fourths of the energy of the electron at rest is electrical and one fourth gravitational, a conclusion which also appears probable on the basis of Lorenz's theory of the electron. Lastly, there is a certain constant in the solution of the differential equation outside the electron which has been identified with the (electro-magnetic) mass of the electron. The present calculations also seem to support this idea and show at any rate that the constant is proportional to the total energy of the electron.

3. On the determination of the range of α-particles from Uranium.—*By* Kamta Prasad.

The paper describes experiments on the determination of the range of α-particles from Uranium. The apparatus used is essentially the same as devised by Geiger and Nuttall, and the modification consists in the use of a Gold-leaf electroscope in place of the Quadrant Electrometer, for the measurement of ionisation current, as this enables a strong field suitable for impact ionisation to be produced with only a small steady source of voltage, available.

Owing to the occurrence of secondary impact the ionisation in the strong electrical field between the charged central rod carrying the radioactive matter and the earth connected guard tube, the pressure ionisation curve is found practically to consist of two straight lines intersecting at an angle. This kink is sharper than what is found with the use of an electrometer and consequently leads to a more accurate determination of the range of α-particles.

An increase of ionisation current noticed at low pressure and confirmed by reference to the curve in the original paper of Geiger and Nuttall has not yet been explained and is being further investigated.

4. On the nature of electric discharge in Gases at low pressure.—*By* B. N. BANERJEE.

Using cold aluminium electrodes in wide cylindrical discharge tubes and a steady non-intermittent source of potential up to 1,000 volts, the discharge in pure helium at low pressure, when observed through a revolving mirror, revealed generally slanting and equally spaced lines of light originating at the anode and extending up to the head of the positive column. Determining the rate and condition of revolution of the mirror and noting the number of lines of glow in the reflected and spread out image of the discharge tube, the frequency of intermittance at the anode was estimated at 10,000 per sec.

These lines of glow in H_2, He and Ne, in restricted regions of positive column, obtained by generally using an induction coil, were observed previously by Spottiswoode, Wüllner, Aston and Kikuchi. Being unable to explain their nature and origin, Aston and Kikuchi described the observed phenomenon as 'Moving striations' and from a measurement of the slant of the lines of light determined the velocity of the so called striations, which however is of the order of velocity of the positive ions moving through a potential gradient usually obtaining in the positive column of helium discharge.

A bright velvety glow like that at the cathode was often, though not always, observed on the anode, and considering Skinner's observations as regards a sharp potential fall at the anode, the general similarity of action at the cathode and the anode is at once apparent.

It is, therefore, concluded that the glow discharge, similar to the spark discharge, is essentially intermittent and that the positive ions originate from the anode just as electrons originate at the cathode. The potential drop at the anode being considerably less than that at the cathode the positive ions, unlike the electrons, do not acquire any considerable initial velocity but drift towards the cathode governed solely by the potential gradient along their path.

Occasionally two intersecting sets of lines of glow were observed in the reflected image of a helium positive column when the latter showed a suggestion of striations in it. Their points of intersection were found to correspond with the portions of positive column showing relatively stronger glow. It is therefore suggested that the other line of glow is probably the track of negative ions and that the phenomenon of striations depends on the presence in the discharge tube of the oppositely charged ions moving in opposite directions with comparable velocities.

5. Seasonal Weather Forecasting.—*By* J. H. FIELD.

Much work has been done by Sir Gilbert Walker in recent years to improve Indian seasonal forecasting by the method of correlation of antecedent ground-surface weather conditions in various parts of the world with subsequent Indian rainfall in monsoon and cold weather seasons.

Recent analysis of the upper-air winds over Agra, from 11 years' records, now shows the high correlation coefficient of ·91 between the strength of west components during the transition period mid-Sept. to mid-Oct. for the band of winds from 5 to 8 km. above Agra. The period of 11 years is short for reliance in such matters, and the coefficient may become considerably reduced in value as further years' data are gathered; but there are physical reasons to expect a marked correlation of this kind. The next 10 years ought to settle more nearly the true value, and if it remains in the neighbourhood of ·80 or more, a distinct and valuable advance in winter forecasting will have been gained. A graph is shown to compare forecasted rainfall with actual subsequent rainfall for the 11 years' period.

Somewhat corresponding signs, for the main monsoon, of a hopeful outcome of balloon records at Bangalore in South India are now showing through, as the result of 9 years of work there, a coefficient of ·91 using 2 factors only. It is not possible, however, on so short a series of years to gauge the true value of this coefficient, but again there are physical grounds to expect a strong connection.

A set of curves is shown to give clear ideas of the meaning of correlation coefficients of values ·76 and ·90 in relation to "frequency curve" of amounts of departures from the normal monsoon rainfall (some 36 inches).

6. The effect of leakage on records of atmospheric potential.—*By* A. VENKATA RAO TELANG.

The paper deals with measurements of the rates of leak of charge over the insulating supports of the electrometer and of the wires leading from the collector to the electrometer. These are compared with the rates of accumulation of charge by the collectors used in obtaining records. The leakage rate was measured by charging to a high potential the electrometer needle and connected wires, insulating it and then observing the deflections at regular intervals. The charging rate of a collector was measured by placing it within an insulated Farady cage of wire gauze and connecting the collector to the electrometer and wires. The cage initially at zero potential was suddenly charged to a high potential and the deflections of the needle observed at regular intervals of time. From these the charging rate can be calculated. The experiments cover the driest and the wettest periods at Bangalore. The results show that for the apparatus installed, the leakage rate varies from less than ·5% of the charging rate in the dry season to near a maximum of 5% in the wettest season when a flame collector is used and about twice that rate when a radium collector is used. Hence the recorded potentials are never less than 90% of the true potentials.

These results and the study of subsequent photographic records confirm the following conclusion, viz:—

1. The potential, usually positive, moves to negative prior to a fall of rain, and fluctuates violently during the rainfall.
2. When the sky is fully or nearly fully covered with clouds, the potential is very low.
3. The potential generally falls steeply just before or after midnight, reaching a minimum before sunrise.
4. The cumulus clouds, often characteristic of the local thunderstorms in April and May cause the potential to reach both high positive and negative values.

7. Rainfall in relation to floods in North Bengal.—*By* P. C. MAHALANOBIS.

This paper gives an analysis of the rainfall for all important floods in North Bengal from 1870 to 1922 (inclusive).

8. Correlation and variation of Normal Rainfall for July, August and September in North Bengal.—*By* P. C. MAHALANOBIS.

The daily, monthly (for the months of July, August and September) and tri-monthly (the above three months taken together) normals as well as tri-monthly variabilities (as given by the coefficient of variation) and a large number of correlations (between different months for the same station and also between different selected stations for the same month) have been recently calculated using all available data from 1870 to 1922. A general discussion of the statistical results is given in this paper.

9. On Rotor Planes.—*By* N. K. BASU.

Since the days when Flettner of Rotorship fame was experimenting on the model of his rotor ship "Buckau" in the Aerodynamische Versuchsanstalt at Göttingen, people began to think whether the principle of Magnus could not be utilized for increasing the efficiency of aeroplanes. Though this idea was much favoured by his assistants and co-workers, Prof. L. Prandtl, Director of the Institute, was decidedly of opinion that the application of rotors could not be of any real help to aeroplane motion. In fact, as late as February of this year, 1925, he wrote in the Naturwissenschaften that "Über die Verwendungsmöglichkeiten des rotierenden Zylinders hatten wir gelegentlich des theoretischen Resultats Überlegungen angestelet, sahen aber bei keiner von uns in Erwagung gezogenen Verwendung, (Flugzeug-flügel, Propellor, Windmühlen flügel) irgend einen praktischien Gewinn. Ich habe meine Ansicht darüber bis heute noch nicht geändert." In spite of such discouraging remarks from an authority like Prandtl, the author undertook a theoretical investigation of the subject. He arrived at results which did justify his optimism. After the work was finished he learnt from the papers that Mr. Charles Gligorin of Austria has actually tried the combination and asserts that he would get a velocity of 300 miles per hour on a full-sized machine (highest speed that aeroplanes have as yet attained being about 250 miles). His general claim is that a Gligorin rotorplane would be three times as fast as an ordinary machine of the same size and power.

In the paper, the author has shown that for certain relative positions of the rotor and the wing, the inclination of the "Downwash" to the horizontal, *increases by an appreciable amount, thereby putting an extra* "Lift" on the wing and taking off some portion of the "Drag." This decrease in the "Drag" and increment in the "Lift," it is obvious, means more efficiency to the machine.

In the first part he has treated the problem from the physical standpoint of Magnus effect and in the second part mathematical expressions for induced downward velocity '*w*.' Lift A and Drag W, have been calculated assuming elliptic distribution of circulation for the wing. It is hoped that when the practical data of Mr. Gligorins' experiments which are at present being carried on in the National Research Institute at Teddington are available, they might be compared with his theoretical ones.

10. The Scattering of light by transparent liquid surfaces.—*By* C. V. RAMAN *and* L. A. RAMDAS.

11. On some magnetic evidence as to the distribution of electrons in the inner M_{32} – and M_{33} – orbits of elements belonging to the first transition group.—*By* D. M. BOSE.

In this paper it is shown from magnetic evidence, that in the first transition group of elements from *Sc*(21) to *Cu*(29), the M_{33} sub-level is first completed at *Fe*(26) and then the M_{32} sublevel is completed between *Co*(27) and *Cu*(29). It is shown how from a proposed scheme of distribution of the electrons in the M_{32}, M_{33} and N_{11} orbits, it is possible to calculate the number of Bohr's magnetons contained both in the atoms and ions of these elements, and that these calculated values agree (i) with the experimental values found by Gerlach for the atoms of *Fe*, *Ni* and *Cu* and (ii) with the usually accepted values for the magneton numbers for the ions of *Ti*, *Cr*, *Mn*, *Fe* and *Cu*, there being slight discrepancies between the two sets of values for the ions of *Co* and *Ni*. Further an attempt has been made to calculate the spectroscopic magneton numbers from the proposed distribution of electrons. It is shown that under certain assumptions, the calculated values agree with the spectroscopically determined ones, except in the cases of *Co* and *Ni* where there is a difference of 1 unit between the two sets of values. This anomalous behaviour of *Co* and *Ni* is attributed to the formation of the M_{32} group of electrons in them; it is supposed that the electrons in the M_{32} and M_{33} orbits mutually act on one another, when both the orbits have not received their maximum number of electrons.

12. On the number of magnetons in the co-ordination compounds of the first transition group of elements.—*By* D. M. Bose.

In the previous paper it has been shown how to calculate the number of magnetons in the ions for the first transition group of elements, from the distribution of the electrons in the M_{32} M_{33} and N_{11} orbits. So far no attempt has been made to carry out the corresponding calculation when these atoms act as co-ordination nuclei in complex compounds. It is well known that many of the co-ordination compounds of *Fe* (ferrous) *Co* and *Ni* are diamagnetic, while similar compounds of *Fe* (ferric) *Cr*, *Ni*, *Cu* are paramagnetic. In some cases the number of magnetons contained in the latter class of compounds is the same as the number contained in the simple compounds e.g. in the case of *Cr* compounds. In two previous communications sent to the Philosophical Magazine and the Nature, the writer has discussed the properties of a large number of complex compounds, and has shown that the magnetic property of the co-ordinating atom depends upon what is called its "effective atomic number." This number which is the sum total of all the electrons contained in the co-ordinating atom, plus the number of electronic orbits which this atom shares with the neighbouring atoms and groups in the complex compound, can be calculated according to a rule given by Sidgwick (Trans. Farady. Soc. 1923/24). In the two previous papers it has been shown that if this effective atomic number of the co-ordinating atom is equal to the atomic number of the inert gas which terminates this group of elements (which in the case of the *Fe* group of elements is Krypton (36), then the co-ordinating compound is diamagnetic, otherwise it is paramagnetic. In the present paper it is shown that the number of units by which the effective atomic number deviates from the atomic number of the next inert gas, is equal to the number of Bohr's magnetons contained in the co-ordinating atom. Further the distribution of the electrons in the *M* and *N* orbits of the co-ordinating atom is shown.

13. On some X-ray spectra evidence as to the successive formation (i) of the M_{33} and M_{32} sublevels in the first transition group of elements, (ii) of the N_{43} and N_{44} sublevels in the rare earth group of elements.—*By* D. M. Bose.

In a previous paper it has been shown from magnetic evidence that in the first transition group of elements the M_{33} sublevel is completed between *Sc* (21) and *Fe* (26), and then the M_{32} sub-level is completed between *Co* (27) and *Cu* (29), while from the magnetic measurements of Cabrera and Meyer evidence can be obtained that in the rare earth group of elements the N_{43} sub-level is completed between *Ce* (58) and *Eu* (63), and the N_{44} sub-level is completed between *Gd* (64) and *Cp* (71).

In the present paper it is shown that the irregularities in the separation of the *Ka* doublets in the lighter elements from *Ca* to *Cu*, as noticed by Siegbahn and B. B. Roy (Arkiv. f. Mat. Ast. O, Fysik Bd. 18, *P*. 1, 1924), can be accounted for on the supposition of the successive formation of the M_{33} and M_{32} sub-levels. More direct evidence as to the successive formation of the N_{43} and N_{44} sub-levels in the rare earth group of elements can be obtained from the tables given by Nishina in a recent paper (Phil. Mag. 49, 521, 1925).

14. On the β-particle tracks due to the K-radiation from lead.—*By* D. M. BOSE *and* H. P. DE.

The purpose of the present investigation was to test Compton's theory of quantum scattering by observing the presence of small recoil tracks in a Wilson's closed chamber, through which a homogenous X-radiation of short wavelength is passing.

A radium tube placed in a hole bored along the axis of a lead cylinder 6 cm. in diameter is placed in front of a Wilson's chamber.

The radiation emerging from the lead cylinder is passed through Aluminium filters, to cut off the softer L and M-radiations from lead. On photographing the tracks produced, it was found that amongst them were a certain number of long range ones whose ranges where such as one would expect from electrons expelled by the absorption of K radiation from *Pb*. There were a number of small tracks in addition. It has not been possible as yet to state whether the shorter tracks are due to recoil electrons or due to some other causes. The investigation is being continued.

15. On the X-ray examination of crystalline substances and our present knowledge of their atomic structure.—*By* J. K. KABRAJI.

I. Crystals, their characteristics, properties, and some laws.

II. X-Rays, their characteristics, properties, and some laws.

III. The early work and theories of Laue, the Braggs, Debye, and Scherer, Moseley, Hull, etc., applying the reflection of X-rays by crystals to obtain evidence, on the nature of the reflecting planes :—

(*a*) Method employing heterogeneous rays ; Laue photographs.
(*b*) Methods employing homogeneous rays :—
  (1) Reflection from well-defined faces; the Bragg ionisation spectrometer.
  (2) Reflection from rotating crystals.
  (3) Reflection from powdered crystals.

IV. The interpretation of the intensities of reflection of—

(1) various wavelengths by planes of various reflecting powers., *i.e.* in Laue photographs ;
(2) monochromatic waves by various planes. Ratio of intensities of 1st, 2nd, 3rd . . orders.

V. The determination of the space-group of the crystal; (a short survey of the theory of space groups and its application to crystal analysis). Conclusions on the positions of the molecules, their orientation and symmetry.

VI. The building up of the atomic model from *X*-ray and crystallographic, and physical and chemical data.

VII. Some of the findings of *X*-ray analysis and their agreement with old-established chemical hypotheses and data.

16. On the crystal structure determination of the hydrated copper formates by a simplified *X*-ray method and inexpensive apparatus.—*By* J. K. KABRAJI.

I. The advantages of the method of Laue-photographs over other methods.

II. Description of the Shearer type of 'home-made' *X*-ray tube; high-vacuum pumps; camera and mount for crystal: coil, electrolyte break, etc.

III. A graphical method of interpreting the Laue-pattern in terms of the reflecting planes of the crystal.

IV. Interpretation of intensities, and characteristics of the pattern. Determinations of the space-group positions and orientations of the molecules, etc.

V. Detailed considerations and speculations in the fixing of the atomic-structure of the two crystals. The position of the water-molecules, their function, and their effect on the symmetry of the crystals.

VI. Similarities and dissimilarities of the two hydrates.

17. Scattering of *X*-rays in liquids.—*By* C. M. SOGANI.

18. Electrolytic double refraction in liquids and vapours.—*By* S. KRISHNAN.

19. A study of percussion figures.—*By* KEDARESHWAR BANERJEE.

20. Laminar diffraction phenomena.—*By* I. R. RAO.

21. On the emission and absorption of the mercury lines $1P$-$3S$, $1P$-$3D$, $1P$-$3d'$ and $1p_2$-$2S$ in long columns of electrically luminiscent mercury vapour.—*By* B. VENKATESACHAR.

It is now established that, of the arc lines of mercury, those of the series $1p_i$-ms and $1p_i$-md are heavily absorbed by luminous mercury vapour under suitable conditions of excitation (Roy. Soc. Proc. A. 100. pp. 150–166 1921). The yellow lines $1P$-$2d'$ and $1P$-$2D$ are also absorbed by luminous mercury vapour but to a much less extent (Roy. Soc. Proc. A. Vol. 105, p. 530, 1924.). The present experimental investigation is undertaken with a view to study the behaviour of luminous mercury vapour in respect of absorption towards lines which belong to different series but whose absorbing centres are the same. In this work an absorbing luminous column 140 cms. long which can be made to carry any current from *0* upwards and a radiator in the form of an end on mercury arc 30 cms. long carrying a heavy current are employed. The main components of the two yellow lines $1P$-$2D$ and $1P$-$2d'$ exhibit very nearly equal absorption. The line $1p_2$-$1s$ is very heavily absorbed whereas the combination line $1p_2$-$2S$ having the same absorbing centres exhibits feeble absorption. The main line and the satellites of the group $1p_2$-$1S$ which are of very unequal intensity in the radiation from a thin luminous layer are nearly of the same brightness in the radiation from a long column, whereas the components of the group $1p_2$-$2S$ have their relative brightness but little altered when the axial radiation from a long column is examined in a Lummer and Gehrcke plate. The line 4916 ($1P$-$3S$) which has no satellites, unlike the two yellow lines $1P$-$2D$ and $1P$-$2d'$, suffers very little absorption. A quantitative study of the behaviour of these and other lines is being made.

22. On the ratio of emission to absorption in electrically excited luminous vapours.—*By* B. Venkatesachar.

A theoretical paper where it is shown that, in certain cases $\frac{\mathrm{E}}{\mathrm{A}}$ varies as the current density. The mercury lines $1p_i$-ms and $1p_i$-md in an arc discharge come under this class. This result has been previously deduced by Prof. Metcalfe and the author from photometric observations on the emission and absorption of the mercury line 5461 A°.

23. Studies on the Spectrum of copper.—*By* P. K. Kichlu.

The spectrum of copper has been studied in the water spark using plates sensitised by nujol. according to the method given by Lyman. The spectrum extends up to 1900, which is about the limit of the quartz spectrograph. Besides the principal pair $\lambda=3247$, 3273, a number of lines between 2200 A.U. to 2000 A.U. come out in absorption. Attempts are made to classify the spectrum of copper, which is more complex than that of the alkalies, and probably contains quartets, in addition to doublets.

24. On the water spark absorption and furnace absorption spectrum of Nickel.—*By* K. Majumdar.

The spectrum of nickel has been studied in the vacuum graphite furnace at 2000°C. and in the water spark, using condensed discharge. The absorption lines are measured, and tabulated. It is shown that a number of chief lines can be arranged in triplets having p-terms in the lowest level. The results are in accordance with the experiments of Gerlach on the magnetic moment of atoms, but do not agree with the series classification given recently by Bechert and Sommer.

25. On the absorption spectrum of aluminium and cobalt.—*By* N. K. Sur *and* K. Majumdar.

The lines of $2p$-ms, and md-series of aluminium have been obtained in absorption at a temperature of 1520°C. At lower temperatures only the principal lines $\lambda=3944$, 3961 are obtained.

The spectrum of cobalt has been studied in absorption in the water spark. The results obtained agree with the series classification recently given by Bechert and Catalan.

26. On the absorption spectrum of iron.—*By* N. K. Sur.

The lines of iron have recently been classified by Laporte, and shown to consist of triplets, quintets and septets. The principal terms are quintet d-terms. The results are in disagreement with Gerlach's experiments, according to whom the free atoms of iron are mostly non-magnetic. The author has studied the absorption spectrum from λ 5000°A to $\lambda=2000°$ in water spark, and have found a number of very strong reversals between $\lambda=2100$ to $\lambda=2200$. The lines do not occur in Laporte's classification and may be more fundamental than the lines which, according to Laporte, originate from the lowest level.

27. On Lande's principle of branching in spectral classification and its application to the classification of the spectra of silicon in various stages.—*By* M. N. SAHA.

Lande's principle may be stated thus: If any ionised element $M+$ has its vibrating electron in more than one fundamental orbit, the spectrum of M will show multiplicities given by $R=J\pm\frac{1}{2}$, where J=inner quantum number of any fundamental orbit of M^+. This principle replaces Sommerfeld and Kossel's displacement law and includes it as a special case.

The author has found that the truth of the principle is illustrated in the relations between the spectra of silicon in various stages. Following the principle, he comes to the conclusion that the spectrum of Si^+ contains quartets in addition to doublets discussed by Fowler, and the spectrum of Si is like that of Neon (multiplets of the second order).

28. Studies on the spectrum of Bismuth, Lead, Antimony, and Tin.—*By* N. K. SUR.

The spectra of Tin and Lead are not simple, but consist of multiplets of the second order, like Neon. Regularities have been obtained in the spectra of Bismuth and Antimony. They probably consist of multiplets of the third order.

29. On a new method of determining the Ionisation Potential of elements.—*By* SNEHAMOY DATTA *and* SATYENDRA NATH ROY.

On the modern theory of the atom, every possible orbit to which the valence electron can go has a definite energy content. The energy corresponding to the orbit at infinity$=V_i e$, where e is the electronic charge and V_i is known as the Ionisation Potential. Similarly the energy of the first radiating orbit ($2p$ state) is $V_r e$, where V_r is known as the Resonance Potential. If therefore an atom already has an electron in the $2p$ state and energy $(V_i-V_r)e$ is supplied to it the atom will be ionised.

In the Bunsen flame coloured by metallic salts we have an atmosphere with considerable fraction of atoms in the $2p$ state, if these are bombarded by thermions from some suitable source accelerated by an electric field, we should expect kinks in the ionisation current potential curve at Voltages V_i-Vr, and V_i respectively. Such expectations are fully realised and the correctness of the method is proved by the fact that the Ionisation Potentials of sodium and potassium agree fairly well with those previously determined by Franck's method.

The method has also been extended to the determination of the Ionisation Potential for Lithium for which no previous determination is on record. The result obtained shows satisfactory agreement with that obtained from the spectroscopic series limit.

30. The absorption spectrum of Antimony.—*By* A. L. NARAYAN *and* L. R. RAO.

The absorption Spectrum of this element, studied with a Quartz Spectrograph, shows line absorption at $\lambda\lambda$2312, 2306, and 2176 at about 1200°C. At low temperatures there is a group of bands extending from λ2305–2250 with an approximately constant interval of about 15 A.U. At higher temperatures another group of bands has been photographed in the region $\lambda=2830$–3000. As the temperature rises continuous absorption however sets in, beginning from the ultraviolet and spreading towards longer wave-lengths as the vapour pressure rises.

This element has been investigated by a number of observers during the past few years but all of them found only continuous absorption. In view of the fact that the arc series spectra of the elements of the fifth group are still undiscovered, these results, together with those of the in the elucidation of series relationships in the arc Spectra of these metals.

31. On the absorption and Series Spectrum of Indium.—*By* K. R. Rao.

Continuing the previous work on absorption of light by Thallium Vapour, the author has studied the absorption of Indium from $\lambda 6000 - \lambda 2000$. The absorption tube was of steel and provided with Quartz windows at the ends and absorption was studied with a Quartz Spectrograph. The absorption spectra of *In* and *Tl* indicate marked similarities. The first members of the series $1\pi_2 - m\delta'$ of both *Tl* and *In* exhibit asymmetrical absorption. In both cases there appear at high temperatures and on the short wave side of $1\pi_2 - 2\delta'$ a channelled space spectrum consisting of asymmetrical bands degraded towards the red.

None of the lines of the principal series appeared in absorption even at the highest temperature used. One remarkable feature is the very marked absorption of the members $1\pi_2 - m\delta'$.

It has been, however, found that there is one remarkable difference between the absorption of *In* and that of *Tl* inasmuch as the absorption of *In* is very feeble compared with that of *Tl*, though the melting and boiling points of *In* are distinctly lower than those of *Tl*. This marked difference may possibly be due to the difference in their valencies.

From consideration of similarities existing between spectra of atoms of like electronic structure attempts have been made to analyse the spectrum of Indium and to find lines with four-fold and nine-fold Rydberg constant. And it has been found that $\lambda = 1749{\cdot}2$ and $\lambda 1625{\cdot}6$ form the first principal pair $1S - 2P_2$, of doubly ionised Indium with a frequency difference $2P_2 - 2P_1$ equal to 4347. The pair $\lambda 1435$, $1530{\cdot}4$ ($\Delta\nu = 4344$) is probably $2P_{21} - 2d$. The term values are found to be approximately $1S = 242800$, $2P_1 = 181300$, the third ionisation potential of Indium corresponding to the largest term being 30 volts approx.

32. Resonance radiation from Thallium Vapour.—*By* K. R. Rao.

The radiation emitted from Thallium vapour in a lateral direction was examined when the vapour was illuminated with light obtained by using different colour-screens. It has been found that the vapour does not emit any radiation when subjected to radiation $\lambda 5350$ $(1\pi_1 - 1\sigma)$ while the lines $\lambda 5350$ and $\lambda 3775$ have been emitted when the exciting radiation is $\lambda 3775$ $(1\pi_2 - 1\sigma)$.

These experiments strikingly confirm the view already obtained from experiments on the absorption of *Tl* vapour that $1\pi_2$ is the ground orbit of the valence electron in the atom of this element.

33. On the nature of Thallium green line $\lambda 5350_1$.—*By* K. R. Rao.

Continuing the work reported to the Indian Science Congress last year and since published in the Proc. Roy. Soc. further experiments are made by the author on the structure of this line and the relative absorption of the main component and satellite. It has been found that the main component is most sensitive to absorption. The absorption of the satellite commenced practically when that of the main line was complete

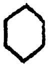
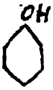
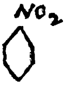
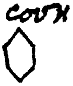
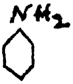
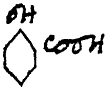
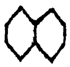
34. The optical anisotropy of Benzene and Cyclohexane.—*By* K. R. RAMANATHAN.

Developing the idea put forward in a previous paper (Proc. Roy. Soc. A. 107, p. 684) that the optical anisotropy of gaseous molecules which is responsible for the partial depolarisation of the light scattered in a direction perpendicular to the incident beam can be explained to a large extent by the mutual action of the electric doublets induced in the different atoms of the molecule by the electric field of the incident radiation, the optical anisotropy of benzene has been calculated for two different structures. Each atom is assumed to be isotropic. If the six carbon atoms are assumed to be in a plane with their centres at the corners of a regular hexagon as in graphite, the optical anisotropy comes out too high even when the hydrogens are ignored. If on the other hand, the carbon atoms are arranged in a puckered ring as in diamond, and the hydrogens are joined to the carbons at the tetrahedral angle, the calculated and the observed values of the optical anisotropy agree well, when the atomic refractivity of carbon is assumed to be that of diamond and the atomic refractivity of hydrogen to be that in gaseous hydrogen. The calculated and the observed values of the molecular refractivity also show good agreement.

The calculation is extended to cyclohexane. The six extra hydrogen atoms are supposed to be attached to the carbon atoms on each side of the approximate plane of the carbon ring alternately. The calculation shows that a considerable falling of in anisotropy is to be expected which is borne out by experiment. The calculated refractivity is also in fair agreement with the experimental value.

35. On the optical anisotropy of some organic vapours.—*By* K. R. RAMANATHAN *and* N. G. SRINIVASAN.

A simple glass apparatus is described which enables fairly accurate measurements of the polarisation of the light scattered transversely by gases and vapours to be made. The apparatus is particularly convenient for substances which are available only in small quantities and for vapours of liquids with high boiling points. New measurements have been made on the vapours of the following substances at temperatures not far from their boiling points :—

Substance.		$\frac{\text{Weak component}}{\text{Strong component.}}$
Carbon di-sulphide CS_2		14·3 %
Ethyl bromide $C_2H_5Br_2$		3·2 %
Ethylene bromide $C_2H_5Br_2$		6·7 %
Benzene		6·6 %
Cyclohexane	C_6H_{12}	1·1 %
Phenol		6·1 %
Nitrobenzene		5·6 %
Benzoic acid		5·3 %
Aniline		4·9 %
Salicylic acid		5.3 %
Napthalene		7·9 %

These measurements and those on related substances made by A. S. Ganesan are discussed in relation to the theory of optical anisotropy developed by one of the writers.

36. The optical anisotropy of some simple inorganic gaseous compounds.—*By* K. R. Ramanathan *and* N. G. Srinivasan.

Measurements of the depolarisation of the light scattered by the gases hydrogen chloride, sulphuretted hydrogen and ammonia are described and the results obtained are discussed in their relation to the structure of the molecules. The depolarisation in a direction perpendicular to the incident beam was in all cases the same, namely 0·08, indicating a high degree of optical symmetry. The value of the anisotropy supports the view that in these gases, the electrons belonging to the hydrogens have gone over to the outer orbits of the heavier atoms, in order to complete the electronic structure characteristic of the nearest inert gas. It is also pointed out that the values of the depolarisation of nitrogen and carbon monoxide, both obtained visually, have practically the same value, supporting the view that the configurations of the outer electrons of these molecules are similar. The error caused in the measurement of the depolarisation of the light scattered by substances owing to the non-parallelism of the incident light is discussed.

37. Resistance hysteresis of Tungsten films under varying pressure.—*By* D. B. DEODHAR.

A tungsten filament bulb was connected with a Gaede pump to create low pressures which were directly read by the McLeod gauge. Calcium chloride tube was inserted in the system for absorption of water vapour. Higher vacua were obtained by connecting Gaede diffusion pump with the box pump.

Resistance was measured with the help of Kelvin's double Bridge and Tinsley's suspended coil galvanometer of which the sensitiveness was 106 mm. per micro amp. at one metre distance.

The following facts were observed from the set of observations:—

(*a*) The initial resistances of the bulbs under experiment ranged from 109 to 111 ohms and beginning from the normal atmospheric pressure the total increase in resistance was of the order of ·9 of an ohm at 10 mm.

(*b*) The rate of increase in resistance with decrease in pressure is greater than the rate of decrease in resistance with increase in pressure.

(*c*) The increase as well as decrease is not uniform over a wide range.

(*d*) On the completion of the cycle of increase and decrease of pressure it takes about four hours for the wire to obtain the initial resistance.

It is obvious from these observations that the molecular alterations effected by changes in pressure undergo a lag and thus the resistance of the filament does not bear a direct proportion to the pressure.

These observations also show that the Pirani vacuum gauge which is based on the principle of variation of resistance due to changes in pressure is not a very reliable gauge.

38. On a direct method of measurement of electrolytic resistances.—*By* A. T. MUKERJEE.

Electrolytic resistances are usually measured by a Kohlrausch bridge. For accuracy, high frequency, pure sinewave alternating currents and special non-inductive resistance coils etc. are recommended. All this means complications and expense. A simple method of obtaining electrolytic resistances from direct measurements of alternating current and potential difference at either low or high frequencies would be of advantage in many problems of interest to the chemist. The rectification properties of a thermionic valve have solved this problem and a robust and accurate low range voltmeter absorbing practically no power and available for very high frequencies is manufactured as the Moullin Patent Voltmeter by the Cambridge Scientific Instrument Company.

Using this method with an ordinary Weston milliammeter for low and a thermal milliammeter for high frequencies the wave form is found to be of little consequence and very consistent results have been obtained. These agree closely with those given by a Kohlrausch bridge.

Typical results obtained on the same electrolyte, Potassium chloride N solution at 29° C, are:—

(1) Kohlrausch bridge	26·45 ± ·03, ohms
(2) 50-cycle A.C. public supply	26·30 ± ·02 ,,
(3) 50-cycle A.C. from rotary converter from 110 volts D.C. Supply	26·36 ± ·02 ,,
(4) Valve-generated high frequency 10^6—cycle current	26·41 ± ·02 ,,

The method has been still further simplified by replacing the Moullin Voltmeter with any ordinary *valve and a student's pattern galvanometer.* Using the 50-cycle A. C. public supply as in item (2) above, this method gave the same electrolytic resistance as 26·84 ± ·02 ohms.

39. On the choice of the striking point in the pianoforte.—*By* R. N. Ghosh.

One of the important problems in the acoustics of the pianoforte is the choice of the striking point which varies from $\frac{1}{7}$ to $\frac{1}{9}$ length of the vibrating string in different pianos. Experiments have been performed by the author which partly solve the problem.

Experimental method:—

A steel wire fixed over two bridges on a sonometer, was struck by felt hammers by a mechanical arrangement which kept the velocity of impact the same in all cases. The vibration curves were photographed and analysed. Two sets of experiments were performed, (1) different hammers striking the string at a fixed distance, and (2) the same hammer striking at different distances a. Harmonic analysis of the curves show the following results:—

(1) the fundamental, the octave and the second harmonic, are strong when $\frac{\tau}{\phi}=2$; τ free period of vibration of the string, ϕ the duration of contact of the hammer with the string. (2) The fundamental is strong when $\frac{\tau}{\phi}=1$ but the other two partials mentioned are then weak.

Hence the choice of the striking point should be such that $\frac{\tau}{\phi}=2$. Now from a musical point of view the ratio $\frac{\tau}{\phi}=2$ is most desirable provided the octave is a true one. Now

$$\frac{\tau}{\phi}=\frac{\tau}{\pi}\left(\frac{T}{M}\right)^{\frac{1}{2}}\left[\frac{1}{a\left(1+\frac{T}{\mu a}\right)}-\frac{\rho}{4M}\right]^{\frac{1}{2}}$$

T = tension of the string.
μ = elasticity of the hammer felt.
M = effective mass of hammer.
ρ = mass of string per cm.

And a cannot be very small for the resulting intensity of the note will then be feeble on account of the presence of sin $\frac{S\pi\tau}{l}$ in the amplitude factor. Further it cannot be very large for then the reflections from the farther end in presence of the hammer on the string would render the partials non-harmonic. Since a must lie somewhere between $\frac{1}{7}$ to $\frac{1}{9}$ length of the string. The best position however is dependent upon the best musical effect. When a is fixed M is determinate. Number (1) was verified in the case of a piano which the author possesses, photographing the amplitude of vibrations of the sound board, and it was found that the amplitude was maximum when $\frac{\tau}{\phi}=1{\cdot}89$.

Another important fact which was observed, is the change of the tone quality with the change in the law of pressure exerted by the hammer upon the string—a law represented by $p = F_1 e^{-kt} \sin qt + F_2\, te^{-Bt}$.

40. Determination of surface tension by the method of ripples.—*By* P. N. GHOSH, D. BANERJEE *and* S. K. DUTTA.

Of the various methods of determining the surface-tension of liquids, the method of ripples is the one which is free from errors due to action of containers. This method has been developed by Matthiesen, Lord Rayleigh, Dorsey, Kalahne, Grünmach and others. The method as developed by Lord Rayleigh, consisting of one tuning fork as the exciter of the ripples and another tuning fork producing the Stroboscopic arrangement for the observation of these ripples, has however produced a diversity of results as computed by different observers as Lord Rayleigh, Dorsey and Kalahne. The final value at the same temperature differ by about 2 dynes. This led the authors to investigate the phenomena more closely. As a result of this investigation, the second tuning fork has been done away with and a fine wire fixed to a light frame is attached at right-angles to the plate exciting the ripples. The plate and the frame being attached to the two prongs of the tuning fork. It has been found that when the ripples generated by the plate are observed with the help of a parallel beam of light incident obliquely on the liquid surface, the intercepted wire appears as a wavy pattern on a bright field. With intense light and fine wire the sinuous curve is sufficiently sharp for accurate measurement of the wave-length of the ripples. The frequency of the tuning-fork has also been very carefully and accurately measured with the help of a Standard Seconds-Pendulum and a Cambridge-recorder. The accuracy of the estimation has been pushed to the second place of decimals. The Wave-length measurement has been performed with the help of magnified photographic image of the curve, subsequently measured with a Hilger Cross Slide Micrometer, correct to hundredth of a Millimetre. Conductivity water has been used all throughout the experiment and the value found in different sets of experiments agree among themselves.

41. On the determination of the frequency of the tuning fork. —*By* J. B. SETH *and* JAI KISHEN.

Two small pieces are attached to the prong of a tuning fork which overlap each other to a little extent when the fork is stationary. When the fork is vibrating a narrow beam of sunlight is able to pass through the slit formed once in every vibration. This makes an impression on a photographic film wrapped round a cylinder which is revolved and at the same time moved at right angles to the beam. Alternate bright and dark patches are thus obtained on the film. In front of the fork is also suspended a simple pendulum which is set in motion and the shadow of an attachment to the bob is cast on the film, appearing as a dark slanting line. The number of bright bands between two such lines gives the number of vibrations of the fork in half the periodic time of the pendulum.

42. On the determination of surface tension by the method of Ripples.—*By* J. B. SETH *and* JAI KISHEN.

Lord Rayleigh's experiment was repeated with this difference that only one fork was used both to produce the ripples and also to intermittently illuminate the moving ripples. Water and salt solution were the liquids experimented on and consistent results were obtained agreeing with the values of S.T. given in the Tables.

43. On the separation of Electricity at the breaking of liquid drops.—*By* J. B. SETH *and* SYAM SUNDER.

This was an experiment with the "Water dropper" using different liquids. The amount and sign of charge on the dropper and the receiver were investigated by means of the Quadrant Electrometer.

44. On Photo-Voltaic cells.—*By* J. C. GHOSH.

Titlestad found that when a polished platinum gauze electrode was dipped in a mixture of Uranyl and uranous salts, the electromotive force of the element is given by the expression

$$=\epsilon+\cdot 028\log[u^{+6}]/[u^{+4}]$$

On exposure to light the electromotive force at the junction changes, the exposed electrode tending to become more negative.

The experimental observation, can be quantitatively explained on the assumption, that in the equilibrium reaction

$$U^{+4}\rightleftarrows U^{+6}+2e$$

the reaction towards the right, *i.e.*, the dissociation of U^{+4} into U^{+6} and two electrons is governed by the energy density of radiation, whereas the combination of U^{+6} with two electrons to form U^{+4} is a purely chemical dark reaction.

Assuming that the chemical potential of U^{+4} is proportionate to its concentration and the energy density of effective radiation, but that the chemical potential of U^{-6} is proportional only to concentration (the temperature being constant, its influence may be neglected) we obtain the following expression

$$\tau=\epsilon+\cdot 028\log\frac{[U^{+6}]}{[U^{+4}]E}$$

where E is the density of radiation.

It follows that doubling the intensity of radiation, will change the potential by 9 micro-volts, according to Titlestad's observations, it is 10 micro-volts.

45. Decomposition potentials in nonaqueous solvents.—*By* S. C. BISWAS.

Decomposition potentials of KI, KBr, LiCl and HCl in pure and mixed solvents of CH_3OH with different percentages of water have been determined with velvety black platinum electrodes. In order to avoid the 'large transfer resistance' potentials of the films on the electrode surfaces a rotating commutator was inserted in the circuit which made the current flow through the electrolysing solutions only for ·009 sec at each revolution. The temperature of the bath was kept constant at 28° C. Values for discharge potentials are found to maintain the same grades of magnitudes as in aqueous solutions, though the values noted in each case have been very low. With dilutions even in pure alcoholic solutions decomposition potentials are found to change. The effect of addition of water in HCl solution in CH_3OH has been found to have a characteristic inflection point at about 1·0 volt which may be attributed to a complex formation between alcohol, acid and water. Decomposition values in pure CH_3OH as noted are given below:—

N.KI- ·32 Volt; ·IN.K.Br-·68 Volt; ·05 N KBr-·71 Volt; ·IN Licl-1.2 Volt; ·5 N HCl-·41 Volt.

46. The temperature of a hydrocarbon flame.—*By* H. K. SEN.

The author calculates temperature of a hydrocarbon flame ($C=84{\cdot}0\%$; $H=14\%$ residues and suphur 2%) from thermodynamical considerations and confirms it from results obtained from the heat balance of an experimental glass furnace. He shows the influence of preheating of the secondary air, and concludes that mechanical atomisation of the fuel oil, instead of by compressed air, should give the maximum available temperature, and incidentally discusses the point raised by Travers why the presence of tar in the producer gases promote the rapid heat-interchange between flame and its surroundings.

Making use of the equations

$$\text{Log } K = \frac{29580}{T} - 2.44 \log T + {\cdot}00074\, T - 2{\cdot}609 \text{ for } CO_2$$

and

$$\text{Log } K = \frac{25029}{T} - 3 \log T + {\cdot}00055\, T + 3{\cdot}33 \text{ for } H_2O$$

the author calculates the following flame temperatures, which are in fairly good agreement with the values obtained by some previous workers:—

Carbon + Oxygen flame	3447·5°	absolute
Oxyhydrogen flame	3280°	,,
Hydrocarbon (C=84%; H=14%) + requisite oxygen	3375°	,,
Hydrocarbon + requisite quantity of air ..	2120°	,,
,, + 10% excess of air	2006°	,,
,, + 2·5% excess air, air preheated to 1000°C	2580°	,,
Hydrocarbon + 10% excess air, air heated to 1000°C	2540°	,,
Hydrocarbon + 10% excess of air, of which 60% is preheated to 1000°C	2540°	,,

47. Propagation of very long electromagnetic waves along overhead power supply lines.—*By* ABINASH CHANDRA SAHA.

Electromagnetic oscillations of low frequency produced by an ordinary Duddell singing arc are transmitted along the main current leads. The oscillations along the various branch lines connected with the power supply mains, are detected by lighting a second arc lamp anywhere with a pair of leads from any branch. The energy of the propagated waves is sufficient to cause the latter to 'sing', the frequency being exactly the same as that of the original musical arc. On raising or lowering the frequency of the singing arc, it is found that the frequency of the detecting arc is altered in a similar manner.

48. On vortex rings in compressible fluids.—*By* NRIPENDRA NATH SEN.

If the motion be symmetrical about the axis of the rings it can be easily proved that "compression" has no effect on the motion of the fluid and, therefore, vortex motion in compressible and incompressible fluids are identical. In his paper on "Vortex motion in compressible fluids" (Proc. Edin. Math. Soc. Vol. 6) Dr. Chree lost sight of this fact.

49. On wave propagation in heterogenous media.—*By* NRIPENDRA NATH SEN.

A simple case of this has been taken up viz., waves propagating vertically in atmosphere. Lamb satisfactorily solved the problem of wave propagation for small amplitude waves only (Hydrodynamics p. 538 also Proc. Lond. Math. Soc. (2) Vol. 7 p. 122) but as matter of fact, amplitude of waves do not remain small. I, therefore, considered *finite amplitude waves* the equation of which can be reduced to a very suitable form solution of which can be determined.

The form of the equation is

$$\frac{\partial^2 y}{\partial t^2}=\frac{c^2\dfrac{\partial^2 y}{\partial x^2}}{\left(\dfrac{\partial y}{\partial x}\right)^{r+1}}$$

which is indentical with equation of motion for wave propagation in the horizontal direction.

50. On some boundary value Problems.—*By* NRIPENDRA NATH SEN.

M. Brillouin in "Compte Rendus" Vol. 150, p. 461–464 and pp. 611–614 gave a process by which functions having specified value over a certain portion of a boundary and their normal derivations having certain given values over the remaining portion of the boundary can be found out. Functions, in Brillouin problem do not satisfy any other conditions. In the problems I have solved functions satisfying a certain class of differential equations over and above the specified values of the functions and their normal derivations. To take up a concrete instance, if in steady propagation of heat in two dimensions, a certain portion of the hot body be kept at specified temperatures and the other portion radiates heat in a given manner, the problem has been solved in some cases. Evidently, the solution may also be applied to hydrodynamics when a certain portion of the boundary is subjected to given impulses while on the remaining portion the normal is prescribed.

51. A note on the change of physical properties of intensively dried liquids.—*By* SASI BHUSAN MALI.

Changes in boiling and melting points occur when liquids and crystals are thoroughly dried by means of pure phorphorous anhydride. According to G. N. Lewis and A. Smits a liquid consists of various kinds of molecules, and intensive drying changes their relative quantities. The author has begun experiments to find out if other physical properties especially refractive index also change with intense dessicating. Results of preliminary observations for Benzene are submitted.

52. The measurement of Radio Signals.—*By* K. SRINIVASAN.

Measurements of the intensity of the electro-magnetic field strength at a point distant from the transmitting station is a matter of the greatest importance and interest. Such fields have very low intensities, 10 to 100 micro-volts per metre, being commonly encountered values, and this necessitates the use of a considerable degree of amplification of the minute voltage induced in the aerial system. Various forms of measuring instruments have been developed in recent years. The apparatus developed by Mr. Hollingworth for the N.P.L. has been adopted as most suitable for the present purposes. It consists of a coil type directional aerial having a resistance capacity coupled amplifier, with a galvanometer in the final stage, and a calibrating circuit. Measuring circuits of this type have now been completed and the observation of the radiation from Madras (Fort) radio are being made.

53. Peculiar wave shapes of currents in the armature of a D.C. Motor.—*By* F. N. MOWDAWALLA *and* G. K. PRADHAN.

A study of currents within the armature of a direct current motor has revealed that under certain conditions these may assume wave shapes resembling those of currents flowing through the armature of a rotary converter. Analysis of a number of oscillograms indicate that these wave shapes are due to the superposition of alternating currents circulating in the closed armature winding on the motor (D.C.) currents. In the case studied these local circulating currents appear to be due to unsymmetrical armature winding. Oscillograms taken with the machine run as generator on load show similar wave shapes.

54. The theory and performance of a polyphase commutator motor.—*By* J. J. RUDRA.

This very interesting but little known machine is treated as a trans former and its vector diagrams, oscillograms and current locii under various operating conditions are given to explain its theory and performance.

55. Equivalent circuits and equations of current locii of alternating current apparatus.—*By* J. J. RUDRA.

The equivalent circuit of a transformer may be obtained from its symbolic equations and the equation of current locus in terms of the constants of the circuit are then determined. The method has been applied to induction motors and a new type of poly-phase commutator motor, after reducing them to circuits similar to those of a transformer. Experimental verification of these equations is also given in the paper.

56. Biased magnetic fields in iron.—*By* K. P. ROY *and* M. PHILIP.

When an iron cored transformer or reactor is subjected to both alternating and direct current magnetisation, its characteristics are considerably modified. The maximum point in the reactance characteristic which may occur at a low value of ampere-turns in an ordinary reactor is considerably shifted when it is biased to a point depending upon the amount of bias which also determines the reactance. The e.m.f. wave is distorted and contains a prominent double frequency term. These properties have been utilised for frequency doublers, treblers, short circuit reactors and voltage regulators. In the usual apparatus the double frequency flux component of the biased magnetic field disappears as the load increases, so that the characteristics no longer represent true conditions of a biased magnetic field. In the arrangement tried a choke coil is used to maintain the exact condition of bias over the load range. Comparative data of the two arrangements has been obtained and experiment shows that the effect of retaining the double frequency flux in the modified arrangement is to increase the value of reactance and the gradient of the reactance characteristic. The magnetising current wave in this arrangement is sinusoidal and the e.m.f. wave distorted, whereas almost the reverse is the case with the usual form.

The iron losses with a biased magnetic field have been separated into the hysteresis and eddy current component losses, and an attempt has been made to correlate the iron losses with the D.C. ampere-turns flux density and frequency.

The paper has been illustrated with the help of Oscillograms.

57. Aerial characteristics.—*By* J. K. CATTERSON-SMITH.

Theoretical considerations show that the current and voltage distribution along an aerial loaded with both inductance and capacity in series has a resonance frequency in accordance with the expression :—

$$L_T = \frac{1}{C_T} \cdot \frac{L_0 C_0}{\theta^2} \pm L_0 \frac{\cot \theta}{\theta}$$

where

$$\theta = \frac{\pi}{2} \cdot \frac{\lambda_0}{\lambda_1}$$

and L_T and C_T are the loading inductance and capacity,

L_0 and C_0 are the static inductance and capacity.

λ_0 is the natural wave-length, and

λ_1 is the loaded wave-length.

If this relation holds then the measured values of the added inductance and capacity in series will give straight line graphs when L_T is plotted to the reciprocal of C_T.

The slope of these graphs is proportional to the wave-length and their intersection gives effective values for the inductance and capacity distributed along the aerial.

By means of a thermionic valve operated high frequency bridge and wave-meter the measurements required to check the above theory have been carried out and at the same time the total resistance of the aerial system measured.

58. Reverse capacity effect in Aluminium electrolytic films. *By* S. SRINIVASA MOORTHY RAO.

When an aluminium electrolytic film is subjected to the influence of alternating current, the plate maintains a positive potential with respect to the electrolyte for some time after the reversal of the applied voltage due to the residual charge in the film and its condenser action.

The present paper shows that even after this positive potential has disappeared, the valve-action does not immediately come into effect.

Wave form records are produced to show that even after the plate has become negative with respect to the electrolyte, the film continues to behave as a capacity and the current voltage relationship closely satisfies the relation :

$$i = C\, dV/dt.$$

From an analysis of the curves an empirical relation for the value of this capacity is deduced.

It concludes by stating that the point of the valve-action is dependent not so much on the disposition of voltages across the film, or the direction of the current through it, as upon the exact state of the products of electrolysis in the film.

59. On the absolute value of Entropy of any system.—*By* M. N. SAHA *and* R. K. SUR.

Ehrenhaft has shown that the thermodynamic properties of any system are determined by a function $\{\gamma\}$, which may be defined as the total phase space described by the system. The present authors have shown that $\{\gamma\}$ is connected with the thermodynamical probability W by the relation $W = \{\gamma\} / \{\gamma\}_0$ where $\{\gamma\}_0$=value of $\{\gamma\}$ at absolute zero. The conception is applied to deduce absolute values of entrophy of both matter and radiation. It is shown that we can reach absolute zero by using either matter or radiation as the working substance, only in a space where all matter has been annihilated, i.e. where there is neither space nor time.

This agrees with Nernst's view of the third law of thermodynamics as the principle of inaccessibility of the absolute zero of temperature.

60. Influence of Radiation on Ionisation Equilibrium.—*By* M. N. Saha *and* R. K. Sur.

Using the conceptions used above, the authors have deduced that the law of ionisation equilibrium take the form

$$\log \frac{x^2}{1-x^2}P = -\frac{(U-Nh\nu)}{RT} + \log \frac{P\nu}{\frac{8\pi\iota^2}{c^3}+P\nu} + \frac{5}{2}\log T - 6{\cdot}5.$$

Applications are indicated.

61. On the motion of eruptive solar prominences.—*By* R. K. Sur.

The author has shown that the motion of eruptive solar prominences cannot be due to electrical forces as imagined by certain investigators. They are due to Selective Radiation Pressure as was first pointed out by Saha, and worked out in greater detail by Milne.

62. Thermal and photoelectric ionisation of gases in solar and stellar atmospheres.—*By* S. C. Roy.

Thermal ionisation of gases is the simplest type of chemical reactions promoted by the action of *radiation* in *temperature* equilibrium with the system, while *photoelectric ionisation* of gases is due to the action of high frequency radiation on a *cold* system. Expressions for the absorption of radiation by a system in temperature equilibrium as well as for that of high radiation by a cold system have been worked out. The coefficient of atomic absorption of radiation in *temperature equilibrium* is inversely proportional to the square of the frequency of radiation absorbed, while the coefficient of absorption of *high temperature radiation* by a *colder* atom varies inversely as the *cube* of the frequency of radiation.

The writer agrees with Eddington and Milne in the conclusion, namely that the probability of capture of an electron by an ion is inversely proportional to the square of the velocity of encounter, but differs with them in the view that the electron has to *hit the nucleus* in order to be absorbed.

The velocity constant of the thermal dissociation of atoms into ions and electrons in the simplest case

$$(\overset{+}{A}\,.\,e \rightarrow \overset{+}{A} + e)$$

is worked out in the form,

$$K_{1_{\text{therm}}} = -\frac{1}{N}\ \frac{dN}{dt} = \frac{8\pi mk^2}{ah^3}\,.\,\bar{\beta}_0\,.\,T.\,e^{-\frac{h\nu_0}{kT}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where, N is the number of neutral atoms per unit volume, and a is the statistical weight of the atom in the normal un-ionised state $\bar{\beta}_0$ is theoretically defined as the *average* '*effective* area' for a recombination-encounter between an ion and an electron at 1°A, and interpreted as representing *physically* the total *atomic cross-section* ν_0 is the frequency of the photo-electric threshold and is determined by the ionisation potential V of the gas according to the equation $eV = h\nu_0$.

The velocity-constant of the reverse process,

$$(\overset{+}{A} + e \rightarrow \overset{+}{A}\,.\,e)$$

of formation of neutral atoms by the recombination of ions and electrons is given in the form

$$K_2 = -\frac{1}{n^2}\frac{dN}{dt} = \left(\frac{8m}{kT}\right)^{\frac{1}{2}} \bar{\beta}_0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where, n is the number of ions or electrons per unit volume.

In the stationary state of thermal equilibrium of the reactions,

$$\overset{+}{A} \,.\, e \rightleftarrows \overset{+}{A} + e$$

$$NK_1 = n^2 K_2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Hence from (1) and (2), the equilibrium constant of the reactions is,

$$K = \frac{K_1}{K_2} = \frac{n^2}{N} = \left(\frac{2\pi mkT}{ah^3}\right)^{3/2} e^{-\frac{hv_0}{kT}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

This is the well-known equation which Saha has applied so successfully to the study of thermal ionisation of gases in solar and stellar atmospheres.

Compton has pointed out that the photoelectric ionisation of gases due to the outflow of radiation from hotter regions of the solar or stellar nuclei might have an effect on the state of thermal ionisation of gases present in comparatively cooler atmospheres. The writer has tried to study this effect in a quantitative manner. An expression has been obtained for the specific rate of total photoelectric ionisation of gases by the action of black-body radiation impressed from an external source at temperature $T°A$ in the form,

$$K_{1_{\text{phot}}} = -\frac{1}{N}.\ \frac{dN}{dt} = \frac{8\pi^2 e^2 v_0^2}{3mc^3} e^{-\frac{hv_c}{kT}} \qquad \ldots\ldots\ldots\ldots\ldots(5)$$

from (1) and (5)

$$\frac{K_{1_{\text{therm}}}}{K_{1_{\text{phot}}}} = \frac{3}{\pi}\frac{m^2k^2c^3}{e^2v_0^2h^3}\frac{\bar{\beta}_0}{a}\,.\,T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

calculations show that the specific rate of total photoelectric ionisation of gases by the action of impressed radiation from an external source at temperature 10,000°A, is about million times less than the rate of ionisation by radiation in equilibrium with the gas at 10,000°A. The consequences of this conclusion in the problem of solar and stellar ionisation of gases have been fully discussed. The photoelectric ionisation of gases in a comparatively cooler regions of the sum and the stars by the outflow of radiation from their interior, is generally negligible compared to the thermal ionisation of the gases by radiation in temperature equilibrium.

63. On the laws of monomolecular, bimolecular, and polymolecular reaction.—*By* S. C. ROY.

The writer develops in this paper his ideas about the role of radiation in chemical reactivity given in two papers to be published shortly (Proc. Roy. Soc., London, and Zeit fur Physik). A typical chemical molecule AB constituted of two parts A and B is considered first. The reactions are represented symbolically as follows :—

$$[AB]_n \rightleftarrows ([AB]_a \leftrightarrows [A]_a + [B]_a) \rightleftarrows [A]_n + [B]_n \ldots\ldots\ldots\ldots (\text{A})$$

where the symbols $[\ ]^n$ and $[\ ]_a$ stand for the 'normal' and the 'activated' states of the molecules. The rate of decompositions of normal AB into normal A and B is determined by the rate of dissociation of 'active' molecules AB into 'active' components A and B.

The reaction $[A\,.\,B]_a \rightarrow [A]_a + [B]_a$ is supposed to be monomolecular and is brought about by a kind of inelastic impact between a molecule $[AB]_a$ and a light quanta hv. The velocity of this reaction is determined by the frequency of inelastic collisions between molecules and light-quantas. The effective 'sphere of action' between a quanta and a molecule during an inelastic collision has a radius proportional to the wavelength of the light-quanta. Instead of a single quanta or a number of quantas confined to a narrow range of frequencies, light quanta of all values larger than a certain initial value hv_0 are capable of such inelastic collisions. The two reverse processes $[AB]_a \rightleftarrows [A]_a + [B]_a$ are controlled by the unit mechanism

$$hv \rightleftarrows \frac{m_A \cdot m_B}{m_A \cdot m_B} . v^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where v is the relative velocity with which the components shoot out in the direction of their line of centres when the molecule is hit by a light quant hv. It represents also the relative velocity of 'head on' collision between the components during a re-combination-encounter.

The velocity-constant of the mono-molecular reaction

$$[AB]_n \rightarrow [A]_n + [B]_n$$

is given in the form

$$K_1 = -\frac{1}{[N_{AB}]_n} \frac{d}{dt} [N_{AB}]_n = \frac{p^a_{AB}}{p^n_{AB}} \cdot \frac{8\pi k^{2m} h}{h^3} \left(\frac{A \,.\, B}{A + B} \right) . \frac{\bar{\beta}_0}{a} . T . e^{\frac{h\left(v^a_{AB} + v_0\right)}{kT}} \,..(3)$$

where, p^n_{AB} and p^a_{AB} are the statistical weights of the 'normal' and 'activated' states of a molecule AB. For all practical purposes $\frac{p^a_{AB}}{p^n_{AB}}$ is equal to the maximum value unity, (according to Bohr's theory A and B are the molecular weights of the components A and B. $\bar{\beta}_0$ is the cross-section of the reacting molecules AB, and the constant is identified with double the number of 'valence bonds' between the components, v^a_{AB} is the effective 'frequency of activation' and may be equal to a sum of a number of frequencies corresponding to the different 'states of activation' through which the molecule has to pass before reaching the final 'reactive state,' v_0 is the frequency of the 'chemical threshold' of 'activated molecules. In the case of reaction involving no preliminary 'activation' or 'loosening of the chemical bonds' to make the molecules ready for dissociation, $v^a_{AB} = 0$.

The writer discusses fully the confusion between the words 'heat of activation,' 'heat of dissociation,' and 'heat of reaction.' It is pointed out that it is futile to look for an absorption band at the frequency

$$\left(v^a_{AB} + v_0\right).$$

The velocity of the bimolecular reaction $[AB]_n \rightarrow [A]_n + [B]_n$ is determined by the frequency of collisions between the activated components, and the velocity constant is given in the form,

$$K_2 = \frac{1}{[N_A]_n [N_B]_n} \frac{d}{dt} [N_{AB}]_n$$

$$= \frac{p^a_A \cdot p^a_B}{p^n_A \, p^n_B} \left(\frac{8k}{\pi m_H} \right)^{\frac{1}{2}} \left(\frac{A + B}{A \,.\, B} \right)^{\frac{1}{2}} \bar{\beta}_0 \, T^{-\frac{1}{2}} \, e^{-\frac{h\left(v^a_A + v^a_B\right)}{kT}} \quad \ldots\ldots\ldots (4)$$

It is argued that,

$$\frac{p^a_{AB}}{p^n_{AB}} = \frac{p^a_A \, p^a_B}{p^n_A \, p^n_B} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Also experimental data on chemical reactions indicate that,

$$v^a_{AB} = v^a_A + v^a_B \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

i.e. the 'heat of activation' of A and B which bound together in the molecule AB, is equal to the sum of the 'heats of activation' of A and B when in the free state.

The equilibrium constant of the reversible reactions

$$[AB]_n \rightleftarrows ([AB]_a \rightleftarrows [A]_a + [B]_a) \rightleftarrows [A_n] + [B_n]$$

is given in the form

$$K = \frac{K_1}{K_2} = \frac{[N_A]_n [N_B]_n}{[N_{AB}]_n} = \frac{(2\pi m_H kT)^{\frac{3}{2}}}{aNh^3} \left(\frac{A \, . \, B}{A + B}\right)^{\frac{3}{2}} e^{\frac{-h\nu}{kT}} \ldots\ldots\ldots (7)$$

N_A, N_B, N_{AB} are expressed in grammoles per *cc* and N is the Avagadro-number.

The expressions given for K_1, K_2 and K are tested by available experimental data on chemical reactions. The agreement between theory and experiment is equally striking in reactions of molecules both in the gaseous state as well as in the state of solution.

Quantitative calculations are given to show that the rate of total photo-chemical decompositions of cold molecules by impressed high temperature radiation is in general million times less than the rate of thermal decomposition.

A brief outline of a theory of poly-molecular reactions is also indicated.

64. On the active modification of Nitrogen.—*By* P. K. KICHLU.

A theory of active modification of nitrogen has recently been given by M. N. Saha and N. K. Sur, which states that when an oscillatory condensed discharge is passed through nitrogen the molecules become loaded with higher energy-contents derived from the discharge, and retain it for considerable time to give the phenomenon of after-glow, which is considered to be the process of falling of the excited molecules to their original states with the emission of their characteristic spectrum. These excited molecules in certain cases transfer their energy to other atoms, which in turn give rise to spectroscopic phenomenon.

The writer has begun experiments with a view to investigate the nature of active nitrogen, and has studied its effects on sodium and potassium, and other metals and compounds. Details of apparatus employed and the results obtained are communicated. In accordance with Saha and Sur's predictions, he finds that *Na* and *K* are very considerably ionised when acted by active nitrogen.

65. Some experiments on metallic reflexion.—*By* G. R. PARANJPE *and* H. D. TENDULKAR.

Comparative results are obtained using a number of different metallic mirrors as regards the percentage of polarized light in the reflected beam and the corresponding angles of incidence which yield on reflexion the maximum amount of polarized light.

On a front silvered glass mirror the reflected beam contains the maximum polarized light when the angle of incidence is 60 degrees.

66. A sensative hot-wire anemometer.—*By* G. R. PARANJPE *and* S. G. NADKARNI.

L. V. King has described an anemometer but its construction and manipulation is somewhat complicated. The construction of the present instrument in based on the observation of minute changes in the resistance of a hot wire when it is allowed to lose heat by exposure to a current of air. Two equal coils of resistance wire are introduced in the two arms of a Wheatsones' net-work. Both coils are originally maintained at a certain temperature and balanced. When one coil is allowed to cool in a gentle air current the balance is disturbed and the deflection of the galvanometer has been shown to render accurate measurements of the very feeble air currents possible.

The sensitiveness of the whole arrangement increases with the temperature, but there is a practical limit beyond which results cease to be reliable.

Low velocities of 14 meters per hour can be very easily measured.

67. Usefulness of Neon-filled lamps in alternating current circuits.—*By* G. R. PARANJPE.

On account of the relatively perfect contrast between darkness and light observed in the appearance of a neon lamp when electric current passes through it and when it does not, these lamps make themselves very useful in A. C. circuits. Bergmann had pointed out some uses to which the following could now be added :—

It can be employed :—

(*i*) in connection with a stroboscope for measuring the speeds of moving objects.
(*ii*) for measuring very small intervals of time.
(*iii*) for detecting synchronism in the movements of the two bodies. This makes the lamp particularly useful at the time of starting Synchronous motors.
(*iv*) in connection with a revolving mirror, as an oscillograph where it is necessary to use two lamps one functioning as a voltmeter and the other as a ampèremeter.
(*v*) as a rectifier for charging small lead cells made in test tubes of a high tension battery as is generally required for radio receivers.

The lamps working on A.C. whose frequency can be controlled can thus be employed almost everywhere when reliable and controllable intermittent light is required.

68. Complementary colours in rotating discs.—*By* A. STEICHEN.

I. On a disc alternating white and black areas are marked. The disc is illuminated simultaneously by two sources of light, one of them gives steady, other intermittent light. The disc is rotated and its velocity of rotation is so adjusted that the disc appears at rest in the intermittent light. The following phenomena are easily observed :—

1. When the intermittent light is coloured by the interposition of coloured glasses then (a) the white portions appear in the colour of coloured light, (b) the black portions take up the complementary colour.
2. When the steady light is coloured then every thing is reversed :—
   (*a*) the black areas appear in the colour of the coloured light.
   (*b*) the white areas take up the complementary colour.

II. Instead of a disc with white and black areas an entirely white disc can be used and areas cut out of it. Then the same phenomena as on the first disc are observed. The cut portions in the disc behave like the black areas of the first disc.

There is perfect similarity between the phenomena here described and coloured shadows.

69. On some peculiarities of Neon lamps.—*By* G. R. PARANJPE *and* K. SHESHIENGAR.

Watson observed some peculiarities like intermittant flashes and lag in lighting up neon tubes in 1913. Schallreuter in 1922 produced some very high frequency oscillations in Neon lamps by connecting them in parallel with a condensor in D. C. circuits. Additional interesting peculiarities have now come to light and some of them are given below :—

- (*i*) A neon lamp with two spiral electrodes made for 230 volts actually lights up when both its poles are brought within 5 mm. distance from the ends of the mains carrying A.C. 155 volts. Metallic contact is not essential. The light is obviously very feeble.
- (*ii*) A neon lamp of 230 volts having one long plate and one short rod for its electrides lights up at much lower P.D. about 125 V. and when the P.D. is still lower than this, the lamp can be lighted up by merely touching its glass bulb with one's fingers. The lighting up occurs either immediately or after a fairly long time depending on the smaller or larger amount of insulation resistance of the body.
- (*iii*) When the lamp is lighted up at a P.D. lower than 125 V. the light becomes intermittent under certain conditions sometimes.
  - (*a*) with regular intervals and at others.
  - (*b*) with intervals gradually increasing until the lamp is finally extinguished.
- (*iv*) Temperature of the lamp appears to be an important factor in producing intermittent flashes. With the bulb immersed in ice and water the lighting up P.D. is as low as 20 v and the period between the flashes some seconds varying somewhat owing to certain other conditions.
- (*v*) There is another interesting effect due to the history of the lamp, depending on its previous use. If the lamp is kept burning for a length of time and switched off, then it is observed that the P.D. at which it lights up again is in definite relationship with the length of time during which it was kept burning previously.

70. On Summable double series.—*By* V. THIRUVENKATACHARYYA.

The object of this paper is to extend Borel's method of finding the sum of Summable double series and to obtain the sums of certain double series

If

$$
\begin{aligned}
S_{m,n} = u_{0,\,0} + u_{0,\,1} + u_{0,\,2} + \dots + u_{0,\,n,} \\
+ u_{1,\,0} + u_{1,\,1} + u_{1,\,2} + \dots + u_{1,\,n} \\
+ u_{m,\,0} + \dots\dots\dots\dots + u_{m,\,n}
\end{aligned}
$$

then it has been proved that

$$\lim_{\substack{x\to\infty \\ y\to\infty}} e^{-x-y} \sum_{0}^{\infty} \sum_{0}^{\infty} S_{m,n} \frac{x^m y^n}{\underline{|m}\,\underline{|n}} = \overset{\infty}{\underset{0}{T}}\ \overset{\infty}{\underset{0}{T}}\ u_{m,\,n}$$

It has been proved that under certain conditions the equation

$$\int_{a}^{\beta}\int_{\gamma}^{\delta} \overset{\infty}{\underset{0}{T}}\ \overset{\infty}{\underset{0}{T}}\ u_{m,\,n}(\theta,\,\phi)\,d\theta d\phi = \overset{\infty}{\underset{0}{T}}\ \overset{\infty}{\underset{0}{T}} \int_{a}^{\beta}\int_{\gamma}^{\delta} u_{m,\,n}(\theta,\,\phi)\,d\theta d\phi$$

Again under the same conditions the equation will be true

$$\frac{\partial}{\partial\theta} \overset{\infty}{\underset{0}{T}}\ \overset{\infty}{\underset{0}{T}}\ u_{m,\,n}(\theta,\,\phi) = \overset{\infty}{\underset{0}{T}}\ \overset{\infty}{\underset{0}{T}} \frac{\partial}{\partial\theta} u_{mn}(\theta,\,\phi)$$

In the concluding position of this paper these results have been applied to some of the double series whose sums have already been found in order to find the sums of certain other double series.

71. On generalised Legendre functions.—*By* V. THIRUVENKATACHARYA.

72. The absolute limits of Space, Time and Matter.—*By* JOGENDRA KUMAR SEN-GUPTA.

The object of the writer in assuming the absolute limit of space has been to avoid the difficulty by the Euclidean development of the Geometry of space due to the absence of any finite relationship between his point and line, and to dispense with his axioms and postulates. Whilst to start with, the Euclidean concept of a point of space agrees with that of the writer in that it is incapable of further division, the writer, unlike Euclid, treats it as the absolute limit of space and as finite, although it is no-dimensional in either case. Then, again, as Space co-exists with Time and Matter in the sense that we can only realise them in relation to one another, for the purpose of their universality it is not unreasonable to assume that like Space, Time and Matter have their absolute limits too, viz., instant and particle. It has been further shown that if the concept of a particle of matter be limited to its only property of occupying space, the idea of dynamical force being foreign to it, we can evolve the theory of uniform motion of a particle of matter, i.e., a particle existing at one point at one instant must exist at a consecutive point at the next instant, and so on, the path of such particle be known as a line. This line, in the writer's concept, is as continuous as the Euclidean line.

73. On the flow of liquids between two coaxial cylinders.—*By* KAMTA PRASAD *and* KESHO DAYAL.

It can be shown that if a cylinder of mass M and radius R enters freely under gravity another cylinder slightly bigger in diameter and closed at the bottom, containing a liquid of viscosity μ, so that the liquid is forced out through the annular space between the two cylinders, the following relation holds :—

$$Vl = \frac{h^3}{6\pi\mu r^3} \cdot M \cdot g$$

where l is the length of the inner cylinder at any moment inside the outer cylinder, V the velocity of descent of the former at the same moment and h the difference in the external and internal radii of the two cylinders.

Experiments have been made with distilled water to test the validity of the above formula. As is well known, corrections have to be introduced on account of the effects of the boundary. Experiments with inner cylinders of different diameters further suggested that as it is difficult to turn in practice perfect cylinders, their variation in diameter at different points of their length requires also to be taken into account.

An empirical correction of the form $a+bl+cl^2+dl^3$ takes account of the two sources of error and is found when applied to the sample formula given above, to give correct valves of the viscosity of water. Here a, b, c and d are constants which are easily evaluated and l has the same meaning as above. The corrected formula then can be written as.—

$$Vl+a+bl+cl^2+dl^3=\frac{h^3}{6\mu\pi r^3}\,.\,M.g$$

74. Periodic Law of Atomic Refractivity.—*By* S. C. BISWAS.

1. A brief review of the work of previous investigators has been made with a view to bring out the meaning of atomic refractivity as has been understood, e.g. works of Calthrop and Le. Bas have been discussed.

2 Suitability of refractivities fitting in the scheme proposed by Grimm have been considered from (1) experimental (2) hypothetical, (3) theoretical grounds.

3. Ionic refractivities are more fundamental than atomic refractivities and they must be in more direct relation with valencies have been remarked.

4. Arrangement of atomic refractivities according to Grimm's branches has been considered and seems to be more natural than the arrangement in the periodic table has been discussed.

5. Mosotti's eqn. for the dielectric constant has been modified by the application of quantum theory by Jones which has been worked.

6. Values of a_n as calculated from these expressions have been compared with Bragg's radii and those of Rankine and Sackur. It is found that relative estimates of atomic diameters by Bragg are much less than the values as calculated.

7. That atomic refractivities might be composed of discrete integral parts of the values of Hydrogen has seemed probable.

8. Grouping of atomic refractivities along those of Inert gases have been considered and a proportionality relation has been obtained of the form $(\mu-1)$ VII, VI, or V groups $\propto$ $(\mu-1)$ rare gas, for corresponding elements of the same L, M, N, O, groups.

9. Davey's law connecting radii in the periodic classification has been stated—which conforms to the law of refractivity very well.

10. Law of refractivity has been formulated with reference to Bohr's order number of levels of outer electrons or according to the branch scheme of Grimm.

The law states that there is a strict proportionality between the refractivities of elements having the same or different levels of outer electrons as with similar and parallel elements having levels exactly as previously similar and parallel means that the difference in the values of atomic numbers must be of same value and of same sign.

75. Projection of Diffraction Spectrum.—*By* S. G. SUBRAHMANYAM.

The paper gives an account of the method adopted to project the solar spectrum formed by diffraction on a screen. This experiment would be a useful demonstration experiment showing the various properties of a diffraction spectrum.

76. Significance of minimum ionising potentials of gases in relation to their molecular volumes.—*By* S. C. BISWAS.

On the assumption that the same electrons that take part in the polarization of a medium under an electric field, are also measured by the work necessary to produce minimum ionising potential, extracted from the molecule, K. T. Compton (Phys. Rev. Vol. VIII. 1916) has calculated the values for minimum ionising potentials or better resonance potentials of a number of gases These values are in a very striking manner found related to the molecular volumes calculated from critical temperatures and pressures data. The relation is thus expressed, minimum ionising potential "V_0" in volts varies inversely as the molecular volume "V".

Or $$V_0 = \frac{1}{b}, \text{ i.e. } vV_0 = C$$

where C is a constant. This constant must have some relation to the molecular heat of dissociation or heat of activation.

77. Some Properties of *M*-functions.—*By* M. VENKATA RAMA AYYAR

[Note :—The M-functions have been defined as

$$M_n(x) \equiv \frac{x^n}{\underline{|n}} - {}_{n+1}A_{n+1}\frac{x^{n+2}}{\underline{|n+2}} + {}_{n+1}A_{n+2}\frac{x^{n+4}}{\underline{|n+4}} - \cdot + \;\cdots\cdots\cdots\cdots,$$

$$\begin{aligned} \text{Where } {}_rA_{r+s} &= \Sigma a_r\ \Sigma a_{r+1}\ \Sigma a_{r+2} \ldots\ldots \Sigma a_{r+s} \\ &= a_r \,.\, \Sigma a_{r+1}\ \Sigma a_{r+2} \ldots \Sigma a_{r+s} \\ &\quad + a_{r-1}\ \Sigma a_r\ \Sigma a_{r+1} \ldots\ldots \Sigma a_{r+s-1} \\ &\quad + \cdots\cdots\cdots\cdots \\ &\quad + \cdots\cdots\cdots\cdots \\ &\quad + a_1\ \Sigma a_2\ \Sigma a_3 \ldots\ldots \Sigma a_{s+1}. \end{aligned}$$

These functions were introduced in a paper on 'Determinants whose elements are specified numbers' in No. 4 Vol. XIV of the Journal of the Indian Mathematical Society and they were identified with sec x, sec x $\tan^m x$, $Cn\ (x, k)$, $dn\ (x, k)$, $Jn\ (x)$, etc., for particular values of a_n.].

In this paper, it is shown that

$$\begin{aligned} \frac{d^n}{dx^n}M_0(x) = (-1)^n . \Big\{ & a_1 a_2 \ldots a_n M_n(x) - a_1 a_2 \ldots a_{n-2} M_{n-2}(x) \,.\, {}_{n-1}A_{n-1} \\ & + \cdot - \ldots + (-1)^{r-1} . a_1 a_2 \ldots a_{n-2r+2} M_{n-2r+2}(x) . \\ & {}_{n-2r+3}A_{n-r+1} + \ldots\ldots \Big\}, \quad \ldots\ldots\ldots\ldots\ldots (\text{I}) \end{aligned}$$

$$\begin{aligned} (-1)^n a_1 a_2 \ldots\ldots a_n M_n(x) &= M_0^{\,n}(x) + {}_{n-1}a_{n-1} M_0^{\,n-2}(x) \\ &\quad + {}_{n-1}a_{n-3} M_0^{\,n-4}(x) + \ldots\ldots\ldots\ldots\ldots (\text{II}) \end{aligned}$$

where $M_0^{\,r}(x)$ means the r*th* derivative of $M_0(x)$.
It is then deduced by integration that

$$\frac{x^n}{n} = M_n(x) + {}_{n+1}a_{n+1} M_{n+2}(x) + {}_{n+3}a_{n+1} M_{n+4}(x) + \ldots\ldots\ldots (\text{III})$$

from which it is seen that any function of x expressible in positive integral powers of x can be transformed into a series in *M*-functions. It is further established that

$$\{M_0(x)\}^2 + a_1\{M_1(x)\}^2 + a_1 a_2\{M_2(x)\}^2 + \ldots\ldots = 1 \quad \ldots (\text{IV})$$

The above results are applied to several particular cases and many neat results are derived, several of which are important formulæ in Bessel's and other functions.

Then, by applying Taylor's Theorem or by the use of operators, the addition-theorem for $M_0(x)$ is got, viz :—

$$M_0(x+y)=M_0(x)\,M_0(y)-a_1\,M_1(x)\,M_1(y)+a_1\,a_2\,M_2(x)\,M_2(y)-\,.\,+\ldots \quad \text{(V)}$$

From this are deduced the well-known addition-formulæ for

$$\cosh(x+y),\ J_0(x+y),\ J_1(x+y),\ dn(x+y),\ Cn(x+y).$$

From (V), it is shown that

$$M_1(x+y)=\{M_0(x)\,M_1(y)+M_0(y)\,M_1(x)\}-a_2\{M_1(x)\,M_2(y)+M_2(x)\,M_1(y)\}$$
$$+a_2\,a_3\{M_2(x)\,M_3(y)+M_3(x)\,M_2(y)\}-\,.\,+\ldots\ldots\ldots\ldots \quad \text{(VI)}$$

whence are derived formulæ for $J_1(x+y)$ and $J_2(x+y)$.
Finally it is shown that $a_n=p_n^2+q^n$ is a sufficient condition that

$$\frac{\{M_n(x)\}^2}{M_{n-1}(x)\,M_{n+1}(x)} \text{ be independent of } x \ldots\ldots\ldots\ldots \quad \text{(VII)}$$

78. Envelopes of Cubics.—*By* M. Bhimasena Rao.

This paper is the outcome of an attempt to discuss the envelopes of cubics which pass thro' m given pts. and touch n given lines, where $m+n=8$. Herein, the case when $m=7$ and $n=1$ is solved analytically. Several of the results got are interpreted geometrically. The method followed is believed to be of help in the solution of the next case when $m=6$ and $n=2$, which has only been partially solved by geometrical methods by H. W. Richmond, F.R.S. in the Edin. Math. Soc. Proc. for 1919–'20. Vol. XXXVIII and by the author in the J.I.M.S. for April, 1920 and June, 1924.

It is obtained that, for the system of cubics passing thro' 7 points of which 3 are chosen as the vertices of the Δ of reference and the remaining 4 are given by $(x_r,\ y_r,\ z_r)$ $r=1,\ 2,\ 3,\ 4$ and touching the curve $f(x,\ y,\ z)=0$, the envelope is

$$f\left(\frac{S_1}{T_1},\ \frac{S_2}{T_2},\ \frac{S_3}{T_3}\right)=0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(I)}$$

$$\text{where } S_1=\begin{vmatrix} y^2 & z^2 & yz & zx & xy \\ y_1^2 & z_1^2 & y_1z_1 & z_1x_1 & x_1y_1 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ y_4^2 & z_4^2 & y_4z_4 & z_4x_4 & x_4y_4 \end{vmatrix},$$

$$T_1=\begin{vmatrix} y^2z & y^2x & z^2x & z^2y & xyz \\ y_1^2z_1 & y_1^2x_1 & z_1^2x_1 & z_1^2y_1 & x_1y_1z_1 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ y_4^2z_4 & y_4^2x_4 & z_4^2x_4 & z_4^2y_4 & x_4y_4z_4 \end{vmatrix}.$$

with similar expressions for S_2, T_2, S_3, T_3. When $f(x,\ y,\ z)\equiv px+qy+rz$, it is shown that the envelope is an universal Octavic with triple pts. at the 7 given points.

When 6 of these 7 pts. lie 3 by 3 on 4 st. lines, it is shown that the Octavic breaks up into the 4 lines and a Quartic curve passing thro' the six pts. and having a triple point at the 7th, whose equation is obtained. . (II).

When the 7 pts. form a Quadrangle and its diagonal Δ, the envelope is shown to be a conic circumscribing the diagonal Δ . . . . (III).

The reciprocal of (III) yields the result that all curves of class 3 inscribed in a Δ, touching the sides of its medial Δ and the line at ∞ and passing thro' the Nagel pt. touch the in-circle. . . . . (IV).

This system of curves includes 12 degenerate cases when they break up into a point and a conic, the conics being 3 pairs of parabolas touching

2 sides of the △ and the corresponding side of the medial △ together with 3 pairs of conics inscribed in the 3 parallelograms formed by 2 sides of the △ and 2 sides of the medial △, the conics in each case passing also thro' the Nagel-pt. Hence all these 12 conics touch the in-circle......(V).

79. The Evaluation of 2 functional determinant with applications.—*By* M. BHIMASENA RAO *and* M. VENKATA RAMA AYYAR.

§. 1. It is shown that

$$D \equiv \begin{vmatrix} f_{1,1}-f_{1,2n} & f_{1,2}-f_{1,2n-1} & \cdot\cdot & \cdot\cdot & f_{1,n}-f_{1,n+1} \\ f_{2,1}-f_{2,2n} & f_{2,2}-f_{2,2n-1} & \cdot\cdot & \cdot\cdot & f_{2,n}-f_{2,n+1} \\ \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot \\ f_{n,1}-f_{n,2n} & f_{n,2}-f_{n,2n-1} & \cdot\cdot & \cdot\cdot & f_{n,n}-f_{n,n+1} \end{vmatrix}$$

where $f_{r,s}$ is a function of the integrade variable s of the $2r$*th* or the $(2r-1)$*th* degree is equal to

$$(-1)^{\frac{n(n+1)}{2}} \cdot \Delta f_{1,n} \cdot \Delta^3 f_{2,n-1} \cdot \Delta^5 f_{3,n-2} \cdots \Delta^{2n-1} f_{n,1} \quad \ldots\ldots(\mathrm{I})$$

where Δ is the usual difference-operator.

Similarly, it is established that

$$D' \equiv \begin{vmatrix} f_{1,1}+f_{1,2n-1} & f_{1,2}+f_{1,2n-2} & \cdot\cdot & \cdot\cdot & f_{1,n-1}+f_{1,n+1} & f_{1,n} \\ f_{2,1}+f_{2,2n-1} & f_{2,2}+f_{2,2n-2} & \cdot\cdot & \cdot\cdot & f_{2,n-1}+f_{2,n+1} & f_{2,n} \\ \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot & \cdot\cdot \\ f_{n,1}+f_{n,2n-1} & f_{n,2}+f_{n,2n-2} & \cdot\cdot & \cdot\cdot & f_{n,n-1}+f_{n,n-1} & f_{n,n} \end{vmatrix}$$

where $f_{r,s}$ is a polynomial of degree $(2r-1)$ or $(2r-2)$ in the integral variable s

$$=(-1)^{\frac{n(n-1)}{2}} \cdot f_{1,n} \cdot \Delta^2 f_{2,n-1} \cdot \Delta^4 f_{3,n-2} \cdots \Delta^{2n-2} f_{n,1} \cdots\cdots\cdots (\mathrm{II})$$

§. 2. Denoting a persymmetric determinant of the m*th* order by enclosing the first and last elements of the first row within rectangular brackets and choosing for elements the 'A' numbers which occur in the expressions for the M-functions when $M_n(x)=\frac{n+1}{x}J_{n+1}(2x)$ and whose numerical values have been tabulated in the Appendix to the paper on 'Determinants involving specified numbers' pp. 122—138. No. 4 Vol. 14 of the J.I.M.S. for 1922., it is shown by applying the above 2 results that the persymmetric

$$[{}_{2n+1}A_{2n},\ {}_{2n\cdot 1}A_{2n+m-1}] \text{ is}$$

when $m=1 \pmod{2n+1}$, $=(-1)^{n(m-1)}$; ....(3)

,, $m=n \pmod{2n+1}$, $=(-1)^{mn+\frac{n(n+1)}{2}} \cdot (m+n+1)^{n-1}$..........(4)

,, $m=n+2 \pmod{2n+1}$, $=(-1)^{mn+\frac{(n-1)(n-2)}{2}} (m+n-1)^{n-1}$......(5)

,, $m=0 \pmod{2n+1}$, $=(-1)^{mn}$..............................(6).

Similarly, it is shown that

$$[{}_{2n+1}A_{2n+1},\ {}_{2n+1}A_{2n+m}] \text{ is,}$$

when $m=n$, (mod. $2n+1$), $=(-1)^{mn+\frac{n(n+1)}{2}}(m+n+1)^n$..............(7)

,, $m=n+1$ (mod. $2n+1$) $=(-1)^{mn+\frac{n(n-1)}{2}}(m+n)^n$...............(8)

,, $m=0$ (mod. $2n+1$) $=(-1)^{mn}$...................................(9).

The results (3) to (9) are verified by direct methods using a modified difference-operator, in a number of cases, among which may be mentioned that by applying (9), the determinant

$$\begin{vmatrix} 5 & 20 & 75 & 275 & 1001 \\ 20 & 75 & 275 & 1001 & 3640 \\ 75 & 275 & 1001 & 3640 & 13260 \\ 275 & 1001 & 3640 & 13260 & 48450 \\ 1001 & 3640 & 13260 & 48450 & 177650 \end{vmatrix} \text{ is readily}=1$$

80. Curve-fitting in cases of seasonal variations.—*By* K. B. MADHAVA.

In a contribution made to the Benares Meeting of this Congress, were determined the indices of seasonal variations of the currency balances in the treasuries in India for a period of about sixty years, by two or three methods; viz. the method of moving averages, the method of least squares, and lastly by an adaptation of a method due to Professor Persons. While these methods serve to give the indices, which are in the nature of weighted averages, for discrete points of time, they fail however to exhibit a continuous periodic curve which may be made to fit given data. The author has worked out certain general empirical formulæ for fitting of such periodic curves and the following summary of the main working results is submitted to this meeting of the Congress. The paper will be illustrated with a number of diagrams showing the goodness of fit of the curves obtained, with respect to certain data; viz. (1) reported births, (2) deaths from specified diseases, (3) proposals for insurance, and (4) Treasury balances.

The general empirical formula for a periodic curve which may be made to fit given data may be taken to be

$$y \text{ or } \left(\frac{1}{y}\right)=A+B\sin(b+x)+C\sin 2(c+x)+D\sin 3(d+x)+\ \ldots\ldots\ldots,$$

in which the member of terms to be taken depends upon the given data.

The solution for twelfth periods—i.e., when values are to hand for the beginning of each month—is:—

$$A=\frac{1}{12}\sum_{0}^{11}y;$$

$$\tan b=\frac{2M_0+\sqrt{3}\,M_1-M_2-\sqrt{3}\,M_3}{M_1+\sqrt{3}\,M_2+M_3};$$

$$\tan 5f=\frac{2M_0-\sqrt{3}\,M_1-M_2+\sqrt{3}\,M_3}{M_1-\sqrt{3}\,M_2+M_3};$$

$$\tan 3d=\frac{N_0-N_2}{N_1-N_3};\quad \tan 4e=\frac{\sqrt{3}\,K_0}{K_1-K_2};$$

$$\tan 2c=\frac{L_1+2L_0-L_2}{\sqrt{3}\,(L_1+L_2)};$$

$$B=\frac{1}{12}\operatorname{cosec} b(2M_0+\surd 3\, M_1-M_2-\surd 3\, M_3)$$

$$F=\frac{1}{12}\operatorname{cosec} 5f\,(2M_0-\surd 3\, M_1-M_2+\surd 3\, M_3)$$

$$C=\frac{1}{4\surd 3}\sec 2c(L_1+L_2)$$

$$D=\frac{1}{6}\operatorname{cosec} 3d\,(N_0-N_2)$$

$$E=\frac{1}{4}\operatorname{cosec} 4e\,(K_0).$$

where

$$d_n=y_n-A$$

and

$$K_i=d_i+d_{i+3}+d_{i+6}+d_{i+9}\quad (i=0,\ 1,\ 2\ .\ )$$

$$L_i=d_i+d_{i+6}-d_{i+3}-d_{i+9}\quad (i=0,\ 1,\ 2\ .\ )$$

$$M_j=d_j+d_{j+2}-d_{j+6}-d_{j+8}\quad (j=0,\ 1,\ 2,\ 3).$$

$$N_j=d_j+d_{j+4}+d_{j+8}\quad (j=0,\ 1,\ 2,\ 3).$$

In the simpler case of the Sixth Periods the constants are :—

$$A=\frac{1}{6}\sum_{0}^{5} y\,;$$

$$B=\frac{1}{2}\operatorname{cosec} b\,(d_1-d_2-d_4+d_5)\,;$$

$$\tan b=\surd 3\,\frac{(d_1-d_2-d_4+d_5)}{d_1+d_2-d_4-d_5}\,;$$

$$C=\frac{\sec 2c}{2\surd 3}\,(d_1-d_2+d_4-d_5)\,;$$

$$\tan 2c=\frac{\surd 3\,(d_0+d_3)}{d_1-d_2+d_4-d_5}\,.$$

81. On the motion of small cylinders through viscous liquids.—*By* J. C. KAMESVARA RAO, *and* K. SURYANARAYANA.

The rates of fall of cylinders of radius of the order of 10^{-4} cm. through water, glycerine and water glass have been determined with a view to test the various theoretical investigations on this subject. It is found that when the inertia terms of the hydrodynamical equations are taken into account as in Owen's solution, the velocity of fall agrees with the theoretical value for very viscous liquids. For less viscous liquids it is found the rates of fall and the path of the cylinders depend on the initial conditions.

82. Experiments on harmonic motions.—*By* S. G. GANAPATI-SUBRAMANYAM.

The paper describes determinations of frequency by the revolving drum method due to Meyer with a slight modification by the introduction of an electromagnet which produced dots on the smoked drum when electric circuit was completed through a pendulum clock.

Experiments (1) Verification of the formula for the frequency of a clamped strip for different thickness and lengths (2) Verification of the frequency of a load at the centre of a string under tension (3) Verification of the laws of damped motion.

83. Disturbances in long range wireless transmission in the Gwalior State.—*By* J. M. GANGULI.

The paper deals with frequent disturbances in the transmission of wireless messages between Gwalior and Sibpuri a range of about 75 miles over a rocky and a hilly land, especially during the summer and the monsoon months and attempts to show their relation with atmospheric conditions and the radio-activity of the rocks.

84. On the effect of magnetisation on Poisson's Ratio.—*By* J. B. SETH *and* SANTI SWARUP.

An optical arrangement for registering the curvature of the steel rod in the two perpendicular direction was used. A slight change in the value of σ was noticed on switching on the magnetic field.

85. Motion of projectiles.—*By* K. KHASTGIR.

In this paper, the motion of a projectile, projected with very great velocity, from a point on the earth's surface has been discussed. The equations used are not the ordinary dynamical equations, but those deduced by the method of vectors. By applying the results of the vector analysis, the gedal equation of the orbit of a particle moving under a central force can be easily obtained. From this equation, the range of the projectile and the eccentricity of the path have been calculated. The ordinary results for a projectile can be deduced, by supposing the velocity of projection to be small.

86. Researches on the tricusped hypocycloid.—*By* A. A. KRISHNASWAMI AYYENGAR.

In this paper, the author expounds, by geometrical methods, some new properties of the Tricusped Hypocycloid that were discovered recently by him in collaboration with Mr. V. Ramaswami Aiyar.

The following are some of the leading theorems discussed in the paper.

(1) If any transversal DEF cut the sides BC, CA, AB of a triangle at D, E, F respectively such that

$$BC\,.\,BD+CA\,.\,CE+AB\,.\,AF=\Omega^2$$

(the segments of the sides being considered positive when measured in the anti-clockwise direction) then the straight line DEF envelopes a fixed tricusp inscribed in the triangle ABC; and this tricusp is also the envelope of the Θ-pedal of the triangle, where

$$\text{Cot}\,\Theta=\frac{\Omega}{2\Delta}-\Sigma\,\text{Cot}\,A$$

(2) If ABC be a triangle circumscribing a tricusp which is the θ-pedal envelope of the triangle, the third tangent through A and the isotomic conjugate of the straight line joining A to the point of contact of BC with the tricusp, are equally inclined to BC, the angle of inclination being θ.

(3) If any two tangents DEF, $D'E'F'$ cut three other tangents BC, CA, AB to a tricusp at (D, D'), (E, E'), (F, F'), respectively then $BC\,.\,DD'+CA\,.\,EE'+AB\,.\,FF'=0$.

This is called the five tangent property of the tricusp.

(4) If the tangents at P, Q, R of a tricusp concur at θ, θ is the focus of the maximum inscribed ellipse of the triangle PQR.

(5) If any tangent to a tricusp cuts three concurrent tangents OP, OQ, OR at L, M, N respectively, then

$$\frac{OL}{OP}+\frac{OM}{OQ}+\frac{ON}{OR}=1, \text{ and } \frac{1}{OL\,.\,OP}+\frac{1}{OM\,.\,OQ}+\frac{1}{ON\,.\,OR}=0,$$

P, Q, R being the points of contact of the concurrent tangents.

(6) If n fixed tangents to a tricusp cut three other tangents p, q, r at the sets of points $(P_1, P_2, \ldots P_n)$, $(Q_1, Q_2, \ldots Q_n)$ $(R_1, R_2, \ldots\ldots R_n)$ respectively such that P, Q, R the mean centres of these three sets of points for any system of multiples are collinear.

PQR also touches the same tricusp.

(7) Given n fixed tangents to a tricusp and a variable tangent cutting them in P_1, $P_2 \ldots P_n$, the locus of the mean centre of these points for any assigned system of multiples is an ellipse having triple contact with the curve.

This is a generalisation of theorem (6).

(8) (i) Any four tangents to a tricusp form four triangles whose centres lie upon a circle of the same radius as the incircle of the tricusp.

We shall call this circle 'C_4', the centre-circle of the four tangents.

(ii) Any five tangents to a tricusp being taken, the centres of the five circles C_4 which they determine lie on a circle C_5 also of the same radius.

(iii) Any six tangents to a tricusp being taken, the centres of the six circles C_5 which they determine lie on a circle C_6 of the same radius; and so on without limit.

These results are analogous to Miquel's and Clifford's circle-chains.

87. Studies in the measurement of electrolytic resistances.—*By* S. C. BISWAS.

Bridge system.

On a study being made of the polarisation effect in an electrolytic cell, the Campbell's bridge assembly is adjusted with a periodic E.M.F. from which the resistance and capacity of the cell have been calculated by equations.

(i) S and R are ratio coils which were kept equal, K the capacity of the cell, and C a capacity in parallel with the adjustable resistance.

(ii) , p, the resistance of the cell, "q" the resistance in the adjustable arm.

Deduction.

Telephones are made much more sensitive with the aid of amplifiers so that even with small electrode areas with a cell capacity of .823, the resistances have been measured quite accurately.

88. Variation of logarithmic decrement with amplitude *and* viscosity of certain metals.—*By* G. SUBRAHMANIAM.

The author has since continued his investigations with wires made of the following metals: aluminium, iron, tungsten, silver, eureka (constantan), manganin, platinoid, phosphor bronze, platinum, nickel, gold, and german-silver. In all these wires the log. dec. in torsional oscillations is found to vary markedly even for small angular twists of the order of a few minutes of arc. In the case of the first eight metals the log. dec. ampl. curves run parallel to the ampl. axis until a limiting twist is reached and thereafter to increase, more or less, linearly suggesting an equation of the form $\lambda_a = \lambda_0 + f(a-m)$, where '$a$' and '$m$' are constants, different of course for different metals. As regards the last four metals the curves admit of no such constant value, but are found to rise proportionately with the amplitude.

With the help of values for log. dec. extrapolated to zero ampl. the absolute coefficients of viscosity are determined for the above metals and are—2·76, 14·16, 8·64, 4·72, 1·50, 1·10, 1·90, 1·99, 1·71, 6·30, 11·79, 9·06—$\times 10^8$ poises respectively. For lead and tin the values are—16·39, 35·72—$\times 10^8$ poises. The method of finding the log. dec. in the case of these two metals where the zero is unsteady affords an interesting illustration of the theory of damped vibrations, oscillating alternately about two centres of origin.

89. On a problem on efflux of gases. —*By* G. SUBRAHMANIAM *and* D. GUNNAIYA.

Starting with the usual hydrodynamical equation for the flow of a compressible fluid (Lamb., p. 25) through appreciably wide apertures, where no account is taken of the viscosity factor, it is shown that the time necessary for equalisation of pressure of a vessel initially containing compressed air with that of the surrounding atmosphere

$$t=\frac{\frac{5}{8}\rho^{\frac{1}{2}}\left(\frac{\sinh 4a}{4}+2\sinh 2a+6a\right)}{\frac{cA}{L}\sqrt{\frac{2\gamma P}{\gamma-1}}}$$

where A is the cross-section of the mouth, c the coefficient of contraction depending on the nature of the mouth, L the volume of the vesssel, P the atmospheric pressure, γ ratio of specific heats, and

$$\cosh a=\left(\frac{\rho_1}{\rho}\right)^{\frac{1}{5}}$$

where ρ_1 is the initial density and ρ the density on the adiabatic equalisation of pressure.

For purposes of verification suitable means are adopted for keeping the vessel in communication with the surrounding air for progressively increasing time intervals and noting the value of the ratio

$$\gamma'=\frac{\text{Log}\,P_1-\text{Log}\,P}{\text{Log}\,P_1-\text{Log}\,P'}$$

for each of such intervals—P' being the pressure to which the enclosed volume rises as it attains the surrounding temp. On plotting all such points against times on the x-axis they are known to lie on a smooth curve and on interpolating the curves for $\gamma'=1·40$ the exact times for equalisation are read off. For three different mouths of diams. 0·685, ·822, and 1·19 cms. The values obtained by experiment are 1·25, ·86, ·41 Sec. and those by calculation are found to be in remarkable agreement with the above, being 1·256, ·8722, ·4162 Sec. respectively.

90. The nature of solid surfaces and the scattering of light by them.—*By* L. A. RAMDAS.

The paper describes the various methods of obtaining perfectly clean and optically perfect surfaces of solid substances like mica, glass, gold, silver, copper, etc., and the nature of the light scattered by them under various conditions.

91. Mono-molecular films on water and their influence on the scattering of light by a water surface.—*By* L. A. RAMDAS.

Many organic substances like the fatty acids spread on a clean water surface as a mono-molecular film. The experimental methods of studying the influence of these films on the scattering of light by a water surface when an intense beam of sunlight is focussed on it are described. The nature of the spreading and the disappearance of these films when the substance is soluble in water or volatile are discussed.

92. An investigation regarding the structure of spectrum-lines.—*By* CH. WALI-MOHAMMED.

Very little is known about the fine structure of Spectrum lines and all the observations made hitherto refer to a few bright lines in the *visible* portion of the Spectrum of an extremely limited number of elements. An arrangement is devised for producing an arc Spectrum in Vacuum and for analysing the spectrum lines by means of a Lummer-Gehrcke Plate made of Quartz used in conjunction with a Quartz Spectroscope and the structure of some lines in the *Ultra-violet* region has been investigated.

93. On an experimental evidence of the variation in the velocity of light.—*By* SATYENDRA ROY.

94. A critical examination of Millikan's data on the charge of Electrons.—*By* C. L. SRIVASTAVA, S. P. CHAKRAVARTI *and* D. V. GOGATE.

95. On the atomicity of e/a and e/a^2 from Millikan's data and data from Zürich.—*By* B. P. SAKSENA, *and* S. ROY.

96. On the correct significance of Dr. J. Mattauch's work on the experimental determination of the law of resistance.—*By* S. N. ROY.

97. On the theory of non-linear partial differential equations of the first order.—*By* HARENDRANATH DATTA.

For a certain equation of the above type, the author has obtained a solution which *cannot* be obtained by any of the methods hitherto known, and which shows that the accepted classification of Integrals of a non-linear partial differential equation of the first order is *inaccurate and incomplete.*

The method used in this paper is quite general, but may not yield all possible integrals (like the one obtained in this paper) of the so-called unclassified aggregate.

Section of Chemistry.

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Presidential Address.

LADIES AND GENTLEMEN,

In proportion as I appreciate the honour that the Executive Committee of the Science Congress has done me by inviting me to preside over the deliberations of the Chemistry section this year, a sense of the responsibilities of the position appears to increase until I scarcely feel competent to fulfil it adequately. The task it involves is not easy at any time, and is becoming increasingly difficult with the growing literature in our Science. The mass of exact and detailed experimental material that has been laboriously collected and recorded in Organic Chemistry during the last hundred years has turned us all into specialists: each one of us has been ultimately forced to settle down and cultivate only a minute patch of this vast field. Whilst reflecting, therefore, during the last few weeks as to what should form the subject of the customary address this year, I felt that instead of treating you with the details of a rather specialised branch of chemistry that has been immediately engaging my attention, however great my personal predilection for it, I should make this occasion an opportunity for laying before you some reflections on a subject in which developments of fundamental importance have been taking place at the present day—a subject which is the direct outcome of the co-operation of the Chemist and the Biologist, and whose fullest development is perhaps conterminous with the vast realm of Life itself. I am fully conscious, however, that in dealing with this subject, I am entering a field in which I play the part of a fascinated on-looker rather than that of an active member of the vast army of workers who have already invaded it.

A century has nearly passed since Wöhler, by his synthesis of urea in the laboratory, deduced the far-reaching generalisation that the constituents of living organisms are not endowed through the operation of an undefinable "vital force," with properties peculiar to themselves, but are capable of decompositions and syntheses governed by just the same laws as are found to apply in the inanimate world. The brilliant researches of Berthelot, Kolbé, Strecker and others, which closely followed, led to the reproduction of many other vital products which had till then been considered to lie solely within the range of Nature's powers of elaboration. These discoveries gave a violent shock to the so-called mysteries of Vitalism. To borrow a military expression, these conquests of the chemist might be compared to the sudden raising of the portcullis of a castle—the hitherto impregnable fortress of Nature (—) and the occupation of numerous posts of vantage in quick succession. This was the first stage in that remarkable progress in organic chemistry to which perhaps there has been no parallel in the history of any other science—a period in which chemists were engaged in the separation, identification and examination of natural products or of substances derived from them by familiar and often long known processes. Chevreul's researches on the fatty bodies, Liebig and Wōhler's investigation of the oil of bitter almonds and its derivatives, those of Berthelot, Williamson, Kolbé and others on the alcohols, ethers, etc, as well as the separation of essential oils and natural alkaloids, may serve as illustrations of the kind of work referred to. The comparison and co-ordination of the results so obtained led in later periods to the recognition of what may be called natural families of chemical substances, gradually ushering in those eras of new compounds, of the problems of their constitution and their application in industries, which have continued to the present day. Indeed, a retrospective survey of these successive stages would fully warrant the belief that the modern edifice of organic chemistry owed its origin and received its inspiration from the desire of the chemist to reproduce in the laboratory such substances as had been built up by the living plant or animal. The extent of the success that has attended his efforts in this field may be gauged from a comparison of those early attempts at reproducing such simple bodies as urea, alcohol and acetic acid with the modern synthesis of a dodecapeptide closely resembling the natural albumens, or of the other complex products of Nature such as a vegetable alkaloid or an anthocyanin pigment.

It must be confessed, however, that these triumphs of the laboratory have been achieved by the chemist by methods which are seldom identical with or even equivalent to those employed by Nature. The history of nineteenth century organic chemistry unfolds a narrative of a marvellous development in carbon chain and cycle syntheses, but does not carry us very far in the way of advancing what must have been the real issue with the founders of our science—*i.e.*, the reproduction of vital products with the object of understanding, and ultimately copying Nature's processes for elaborating these.

The causes that led to this digression are various and need not be detailed here. I would only refer to what was probably one of the deciding factors in creating this diversion—the discovery of coal tar and all its wealth of benzenoid substances. The question as to what might have been the course of development of our science had this discovery not been made, and we were left to the resources of Hofmann in his early days in the Royal School of Science, for preparing a few grams of aniline at the end of a full day's labour, has often appealed to me as offering an interesting subject for speculation. The competition and struggle for the commercial exploitation of every new discovery in our science which followed the separation of even the first few fractions of coal tar, left little leisure, even if there was inclination, to the large majority of the workers to inquire into the methods of the living machine. Besides, such an inquiry was generally believed to be of purely academic interest and not of any practical benefit to humanity. And yet when we reflect for a moment, and consider the extent to which we depend for our very existence on the synthetic preparations of the laboratory and on those given us by Nature, the endeavour to appreciate how and why certain compounds are produced in plants and animals can scarcely be dismissed as merely of scholastic value. Indeed it is not inconceivable that the processes occurring there, when understood more clearly, will be found to be not only simpler but more efficient than our present day laboratory methods. It may perhaps be objected that it is only expressing a pious hope and nothing more, there being so little experimental justification for it at the present moment. Even if this be so, it need scarcely be pointed out that our attempts at acquiring greater mastery over the secrets of biochemical processes cannot fail to bring us into possession of such definite information regarding the evolution and functions of the diverse compounds found in the living organism as will lead to the discovery of fundamental principles and profoundly influence such important branches of knowledge as Agriculture and Medicine. The discovery of insulin, probably a protein enzyme complex, and its functions in relation to diabetes mellitus which is the result of a steady advance along already foreshadowed lines of investigation, may be cited as a significant illustration of this.

I have referred to the discovery of coal-tar and its industrial possibilities as one of the disturbing events of the last century which drew the chemist away from the problems of vital chemistry, but there were other factors which contributed in no small measure to the same result. One of the most important of these was the almost morbid antipathy shown by the orthodox chemist to the investigation of anything that was not characterised by a crystalline structure. Our laboratory experience of a vital product generally commenced at the point when out of the muck of the enveloping and interpenetrating gelatinous mixture, usually met with in Nature, we had succeeded in dragging some one definite crystalline individual and having it free from what was regarded as defiling impurity, we proceeded to analyse and ultimately synthesise it if possible. Yet time has forced the lesson upon us that there is a vast and a most important tract of the material world not characterised by any of the typical crystalline structures but which falls under the category of the so-called "mess"—the colloids. It is strange that our appreciation of its importance should have come so late considering the fact that all living things with their infinite manifestations of changes are steeped in colloids. The plastic elements of the plant and animal body are all found to belong to this class, their peculiar physical aggregation and singular inertness in acidic and basic functions making them specially fitted for interacting in the organic processes of life. Happily this preconceived bias of the organic chemist in the past is fast giving way before the active inquiry that is proceeding now into the nature of these organic colloids—the unvarying and essential constituents of the living cell. New ideas about living structures are being born out of the productive investigations of the highest order that have taken place in this field in recent years, and we may well be on the eve of another great advance in the present century which will bring us nearer the realisation of what has been Man's dream from the earliest times—viz. the lifting of the curtain from the supreme mystery that enshrouds and probably ever will enshroud Life.

I shall now proceed to consider some of the main lines in which the problems of vital processes particularly in plants are being attacked at the present day, and in which discoveries of fundamental importance are likely to be made in future.

The most logical course appears to be to consider the subject in the sequence in which it has been developing during the past two decades—the steadily advancing knowledge of the reagents elaborated by the living protoplasm and the mechanism of their action, the manner in which the energy of the sunlight is trapped and built into chemical energy for the synthesis of its essential requisites of growth—the proteins and carbohydrates, and finally of the various degradation processes involving the release of the energy locked up in the molecules of these antecedent products.

To a class of men who had early realised the necessity and importance of a proper understanding of the chemical processes taking place in the living organism but who, by reason of their general indifference to scientific methods, perhaps rightly deserved the epithet of 'quacks,' we are chiefly indebted for the present renaissance in our science—I mean the return of organic chemistry to the main theme from which it departed nearly a century ago. Being better trained in the methods of science, the chemists, or at least some of the best minded of them, quickly perceived the tremendous possibilities of this line of investigation, and it has been mainly through their entrance into the field that the old science of biology is being given an exactitude that had not hitherto been considered possible.

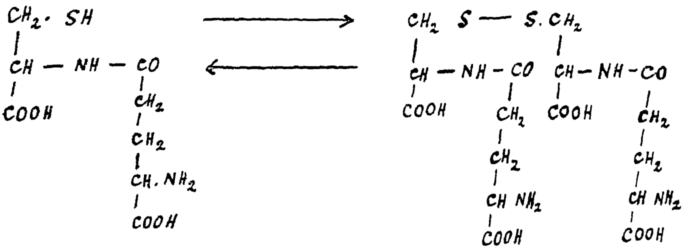
After the long drawn controversies of Bishop Needham and his pupils and their antagonists, the position of the spontaneous generation theory seemed to have neither prospered nor declined when Pasteur published his classical memoirs on bacterial action and sterilisation and showed that fermentations would not occur in media in which all living organisms had been killed by heat. There was thus brought into the ken of accurate scientific investigation the presence and influence of those myriads of animalcules with their diverse functions which were the responsible agents in bringing about the transformations in plants and animals. It is not my purpose, even if I had the qualification to do so, to trace the development of the technique of researches which culminated in the opening of such altogether new branches of science as bacteriology or micrology, but I merely wish to draw your attention to the most significant change in the angle of vision that was effected through these discoveries and improved methods of experimentation. The more intensive study of the changes occurring in Nature which followed these researches, and which received a great impetus from the remarkable results obtained at about the same time by Fischer regarding the composition and structure of many of the complex bodies of living tissue, led to the knowledge firstly, that these biochemical transformations were not so complicated as they had been imagined to be at the beginning, but were of the same order as the simple hydrolytic and oxidative changes involving the rupture of the carbon chains, secondly, that they could be produced in the laboratory with the aid of freshly prepared extracts of animal or vegetable tissues, and lastly, that these had properties fundamentally similar to those of many of the inorganic catalysts with which chemists had long been familiar The suggestion thus became inevitable that most, if not all of the reactions associated with the living cell could be realised in the laboratory with the aid of the lifeless products of these cells; the conclusive proof of this, however, was not forthcoming until the close of the last century when Buchner gave his experimental demonstration of the fact that the juice obtained from ruptured yeast cells prepared with such precautions as ensured the complete absence of living cells, still retained unimpaired its power of converting sugar into alcohol. The most important consequence of this discovery was the universal recognition that the process of fermentation did not require the co-operation of the living plant but only its agents, we now call the enzymes, which are capable of bringing about the observed chemical changes even after the death of the organism or separation from the cell in which they were manufactured. The further study of these agents, their distribution, classification, mechanism of action, etc, has attracted so many workers and led to developments in so many directions that it would be hardly an exaggeration to say that modern Biochemistry has become virtually synonymous with the chemistry of these bodies. The answer to the fundamental question what is an enzyme is still however incomplete, and will probably remain so, as long as we are unable to isolate the enzyme itself and have to rely on the device of proving its presence from the occurrence of the reactions which it brings about. Enzymes are stated to have been prepared in solution (—) this is obviously incorrect in the light of modern views of enzyme action taking place essentially at solid surfaces and not in solution—as well as in the solid condition, but they have usually been obtained in a highly impure state, the reagents like alcohol, acetone, etc., which are used for their precipitation, serving also to throw out of solution such substances as the proteins or the carbohydrates which invariably accompany them in the tissue fluids. This is no doubt largely responsible for much of the conflicting evidence one comes across in current literature regarding the chemical nature of the enzymes which are regarded as proteins themselves, or compounds of proteins and carbohydrates or even as adsorption complexes of an active principle like a Vitamin or a Hormone with a nitrogenous colloid. A mass attack on the chemistry of some of the common enzymes like Invertase, Maltase, Emulsin, and others has been recently commenced by Willstatter as a first step to the complete overhauling of the subject, and it may be hoped, in view of the brilliant successes of this investigator in other fields of plant chemistry, that further information on the subject would be available in the near future.

While the enzyme still eludes our grasp, the persistent efforts of the chemists to straighten out the tangle have however borne fruit in other directions. Many of our modern ideas regarding the properties of those large aggregates of giant molecules—the colloidal systems, our notions of the great extension of surface area in these bodies, the remarkable concentration changes due to surface action conveniently grouped under the name of 'adsorption,' the influence of hydrogen ion concentration of the media on the colloid particles and their behaviour at the iso-electric point, the theories of membrane equilibrium of Donnan and Loeb, etc., are some of the numerous developments in this field which may be traced directly or indirectly to this source. The importance of these results, moreover, can hardly be overestimated, affording as they do a valuable clue to the great variety of chemical actions that take place at the surfaces forming the cell walls in the living organism.

Whether the chemist will ever succeed in doing away with the vital origin of the enzyme by synthesising it in the laboratory, it is not possible to state with any assurance now, but of considerable interest from this point of view is Dony-Henaults' preparation of an artificial 'laccase' by the precipitation with alcohol of a solution containing gum arabic (10 grams), manganese formate (1 gram), and sodium bicarbonate (4 grams) in water (50 c.c.). This substance, which is undoubtedly a colloidal complex containing manganese hydroxide, has been found to have the properties of Bertrand's "laccase" and to be of almost the same degree of activity. The function of the gum appears to be that of a stable colloid which keeps the manganese hydroxide in a permanent highly divided condition so as to maintain a large active surface. The question naturally arises, therefore, as to whether enzymes too are not made up of similar systems,—a suggestion which derives considerable support from the observation that the ashes of almost all enzymes contain an inorganic residue. The nearest approximation to this conception has been attained in the case of those interesting groups of substances called oxidases which play such an important role in plant and animal life. These bodies have now turned out not to be just simple enzymes but a complex system consisting of at least two constituents—an autoxidisable substance capable of forming a peroxide with molecular oxygen and an enzyme called a "peroxidase" which accelerates the decomposition of the peroxide and liberates atomic oxygen which is the primary oxidising agent of the cell.

A clearer illustration perhaps of this idea would be afforded by the following example: If a mixture of lactic acid and hydrogen peroxide be taken, it is found that oxidation proceeds with extreme slowness, whilst the addition of a minute quantity of ferous sulphate accelerates the oxidation beyond all proportions. If, now, instead of the iron salt the peroxidase, say of the horse-radish plant, be added, the reaction is found to be accelerated in precisely the same manner. The conclusion has therefore been drawn by Perrin and others that an oxidase is the combination of a hydrosol of ferric or manganic hydroxide with a hydrophile colloid. Willstätter and Pollinger who have recently studied this question very carefully have pointed out, howevei, that although no oxidase preparations could be made entirely devoid of iron, the content of the metal was in no way proportional to their activities.

In connection with the nature of the second constituent, the newly discovered glutathione, an autoxidisable substance of a special type, should call for some attention. It is a dipeptide of cysteine and glutamic acid, which has been found to be widely distributed in animal tissues and also in yeast cells though in only small quantities (·01 to ·02%), and is intimately concerned in the oxidation processes of the cell. It owes its importance as a catalyst to the fact that its thiol or sulphydryl groups are readily attacked by molecular oxygen with the formation of a disulphide compound of the type of cystine, which is rapidly reduced back to the thiol form again, the tissues themselves supplying the necessary hydrogen atoms and thereby becoming oxidised :



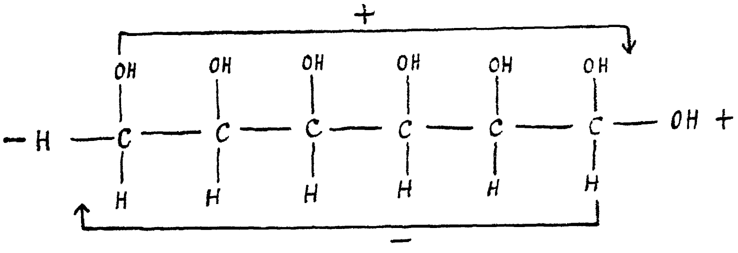
Glutamyl Cysteine
(Glutathione)

Glutamyl Cystine

The power of the cell to bring about these changes spontaneously has been clearly demonstrated by Hopkins who allowed fresh tissue to autolyse with glutathione under anaerobic and aseptic conditions and showed that while oxidation rapidly took place in a neutral or faintly alkaline medium (P_H, 7·4) as seen by the decolorisation of methylene blue if the experiment was carried out in its presence, the reverse change *i.e.* the reduction of disulphide as readily occurred when the medium was rendered faintly acid (P_H, 6·8). There can be little doubt, therefore, that glutathione and presumably similar other autoxidisable bodies, still undiscovered, afford in the tissues a mechanism capable of accepting either hydrogen or oxygen and thus promoting processes of oxidation and reduction which would not occur in their absence. The existence of this dipeptide rather than that of cysteine itself in the tissues has been attributed to the fact that it oxidises more slowly than cysteine, and thus offers the necessary resistance to metabolic changes.

I might at this point make a passing reference to the long known but hitherto little understood problem of the specificity of an enzyme—its partiality for certain definite substances on which alone it will react leaving other bodies untouched. The large amount of evidence that has been accumulating on the subject has at least helped to throw light upon the remarkable manner in which an enzyme really acts. The true significance of the old simile that the enzyme must needs be adapted to the substance on which it is to act—the substrate as it is termed—just as a key must be adapted to the lock which it is to open, is being realised from the recent picture of the enzyme as drawn by Armstrong—an "aggregate of complex organic substances possessing an elaborate structure and containing a variety of radicles. The molecules are oriented at the large active surface of the colloid aggregate in such a way that certain groups are exposed and highly active whilst others are directed away and rendered inoperative, thus endowing the enzyme molecules with selective powers of so fine a character as almost to merit the description of intelligence." Specificity implies, therefore, nothing more than that peculiar interdependence—and not likeness as sometimes erroneously stated—between the architecture of the enzyme molecule or its active part and that of the substrate which gives it the power to anchor or lodge on the latter. It needs no great stretch of imagination to perceive that only substances of a definite structure could fit in or associate with the surface, whilst a slight variation in this, or in that of the enzyme colloid would prevent all action.

Coming to the consideration of the other explanations that have been advanced from time to time of the selective action of an enzyme, I might mention the interesting though still inadequately appreciated theory of Collie, as it offers rather a unique interpretation of the reactions of sugar fermentations. Collie compares the molecule of a sugar to an electrolysing system as will be apparent from an examination of the structural formula of, say, an aldohexose in its hydrate form:—



Aldo-Hexose (Hydrate)

If we now imagine a pair of terminals inserted in the molecule, the hydrogen atoms would be drawn to one side—the left, whilst the hydroxyl groups would move to the right. This would give us the same accumulation of hydrogen atoms at one end and hydroxyl groups at the other which is so well adapted to the chemical representation of the course of sugar fermentations. If we are further permitted to picture the enzyme as inserting the electrical terminus into the molecule of the sugar, not necessarily at the two ends of the chain but at any point in the molecular structure which is spatially suited to their entry, we might be able to account perhaps for the selective action of different enzymes.

It will be seen that the theory involves the assumption of an electrical charge on the enzymes. Indeed, statements to the effect that enzymes are electrically charged bodies are of common occurrence, but probable as this may be, it is perhaps premature to lay much stress on the fact until we are sure that we have pure enzymes in our hands.

Again, the nature of combination of an enzyme with its substrate has been the subject of considerable discussion in recent years. Is it only a physical process of surface concentration of the molecules of the substrate to the colloidal enzyme particles or one of a more strictly chemical nature in which the combination between the two and the breaking up of the resulting complex forms two consecutive chemical reactions ? This still remains indefinite, although as has been remarked by Armstrong, the difference between the rival theories may, after all, be perhaps only one of phraseology. The one pictures the formation of an unstable intermediate complex with the substrate at the surface of the colloid aggregate, the attractive force being chemical, whilst the alternative theory regards the change as being preceded by adsorption at the large active surface of the enzyme, the layer being little more than one molecule thick, and the attractive force being physical. Whatever be the correct view, the conception is daily gaining ground particularly from the results of recent experiments in which the relation between the rate of an enzyme action and the proportion of enzyme to substrate has been quantitatively studied, that the enzyme and the substrate do rapidly enter into some kind of union, and it is only that portion of the substrate which is thus combined that undergoes further chemical change. As long as there is sufficient excess of the substrate, the enzyme will be completely "saturated" with it, so that the concentration of the combined substrate, and therefore the rate at which decomposition occurs, is maintained constant for a long period—a marked contrast to a reaction not catalysed by an enzyme in which the progress slackens from the very commencement as the reacting substances become used up.

Notwithstanding all that has been said, however, the precise manner in which an enzyme performs its function of accelerating a chemical change still remains a mystery. We may imagine the enzyme molecule undergoing temporarily some subtle change in configuration, thereby imparting a shock to the substrate the consequence of which is manifested in the chemical change of the substrate. Such a conception recalls the old view of Liebig that the changes brought about by micro-organisms were due to molecular vibrations which were set up by the living protoplasm and which were of sufficient strength to shatter the molecules of non-living materials which came in its vicinity. In fact, problems like these compel us for the time being to fall back upon the old idea of some subtle, though not perhaps transcendental, agency operating in nature which we have not succeeded in fully fathoming yet. Admitting, however, this picture of the enzyme molecule oscillating between the different configurations, the action may be supposed to continue until the substrate has been decomposed or the character of the environment has altered to such an extent by virtue of the elaboration of the products of its activity, that it will have either lost its power of lodging on the substrate, or its activity will be completely inhibited. The peculiar sensitiveness of an enzyme to its environment has long been known, and enables us to understand the great importance of P_H values of tissue fluids in plants and animals. Since all enzyme reactions are of the nature of hydrolyses or of additions or withdrawals of hydrogen ions, the existence of an intimate connection between the concentration of this ion in the liquids and the action of the enzymes should only be anticipated. They represent a condition of the menstruum favourable or inimical to the necessary transformations of the enzymes.

The various other factors affecting enzyme action such as the influence of temperature, concentration of metallions, etc., or the action of the various co-ferments and anti-ferments constituting a protective mechanism for plant or animal tissues, which have been brought to light in recent years, would no doubt supply themes of surpassing interest, but it is hardly possible to discuss them here. I would only take this opportunity of drawing your attention to what appears to be an interesting parallel between the "anchoring" idea of enzyme action mentioned above and the underlying principles of Chemo-therapy—*i.e.*, the treatment of infections in animals by chemical specifics. Whilst there still remain many apparently irreconcilable facts in this extremely promising field of research, the outstanding feature of Ehrlich's theory, namely, the selective action of chemical specifies—dyes like Afridol-Violet, Baeyer 205, Fourneau 309, etc., or the now familiar organic compounds of arsenic, antimony, mercury, etc., which react upon the protoplasms of parasites without injuring those of the host seems, in its simplest form of statement, not to differ very materially from the conception of the specificity of enzyme action on which so much stress has been laid. It may be incidentally observed that the two dyes, both derived from benzidine, which have hitherto had a genuine success in the treatment of diseases of protozoal infection, are Trypan Red discovered by Ehrlich and Shiga, and Trypan Blue prepared by Mesnil and Nicolle, and it was with the aid of these, and through the development of the technique in the hands of Laveran and Mesnil by which a particular strain of trypanosomes could be passed through a series of mice and other animals of the same species so as to produce an infection of standardised type and virulence, that it has now been possible to show that the original theory on which Ehrlich proceeded was not sufficient, the chief disagreement lying in the inability of the dye to kill the same parasite when occurring in different animals. We seem thus to be confronted once more with the same problem of medium or environment the importance of which must be recognised in all our attempts at initiating any changes in living tissues. Such influence of the medium in activating or paralysing the enzyme has been repeatedly encountered before, and serves to bring out more clearly the analogy subsisting between the two types of action—the action of the enzyme on the substrate, and that of the chemical specific in protozoal infection. The great importance of the rôle played by the medium, whether in the plant or in the animal, is thus just dawning upon our intelligence; we are beginning now to perceive that our attempts at copying nature and combating her by her own instruments can never be completely successful until we are able to control the environment, or at least to secure an identity of conditions—a task which seems to be beyond human powers at present.

Whilst the complete solution of the enzyme problem still remains at a distance, the knowledge gained in the past has been of undoubted value in providing us with some good working hypotheses for gaining further insight into the working of the vital machine. It is true that there are many imperfections still gathering round these hypotheses, and facts hard to reconcile with them, but a little consideration will serve to show that most of these have proceeded from our routine habits of thought and old world conceptions of chemical reactions based upon representation by equations which aim at giving finality to a process, rather than indicating the various possibilities of a balanced reaction. Such an outlook has obviously arisen from the limitations of our experimental vessels which are so fundamentally different from those employed by the living organism. The apparatus of Nature is made out of cellulose with semipermeable walls immersed in a diversity of solutions differing in nature and concentration from solutions inside, and serving at once as containers, filters, and concentrators Here, then, is the possibility of infinite gradations of reaction to which we have no laboratory parallel, and the result frequently is the appearance of products scarcely anticipated by our finite chemical equations. Yet the laws of mechanics are never failing and apply with as much force to these unexpected "averagings" of Nature as to our ordinary laboratory reactions. The absorption of energy for a particular synthesis and its liberation on the breakdown of the complex molecule are always the preponderating factors, and should be perfectly equatable, if I may use such an expression. The fact that we can rarely draw up an exact energy balance sheet in the case of the complex changes of the living world is due to our ignorance of the course of these changes rather than to any departure from the usual laws governing such changes in the reactions of the living cell.

It is well known that energy must be supplied to the molecules in every chemical reaction, but our laboratory devices for effecting such energy changes by means of solvents, application of heat, etc., are obviously inapplicable in vital reactions. The numerous instances of the effect of ordinary or plane-polarised light in stimulating or initiating chemical changes in the plants, such as those observed by Miss Semmens in the case of the rapid erosion of starch granules in the presence of diastase at a low temperature, or the bursting of winter buds by continuous illumination observed by Neithammer, to quote only two of the most recent examples, have made it abundantly clear that the required increments of energy for vital syntheses in Nature are always provided in the form of light. The fundamental process, therefore, which is now regarded as the true origin of all life, is the transformation of the radiant energy of sunlight into chemical energy which, through the medium of plant life and with the aid of the enzymes, is made available for the animal organism. The old hypothesis of Baeyer, though still lacking direct evidence on account of the difficulty of proving the indubitable presence of foramldehyde in plants, may now be accepted without reservation, as the amount of indirect evidence in its favour is positively overwhelming. That formaldehyde is produced by the action of sunlight in the visible region of the spectrum on a saturated solution of carbon dioxide in the presence of chlorophyll or such synthetic photocatalysers as malachite green or p-nitroso-dimethyl aniline, or even metallic salts like colloidal ferric and uranic hydroxides, has now been experimentally verified, and may therefore be accepted as well-established truths. Further, the process of photocatalysis has now been proved to consist in the absorption of light of longer wavelength than 350 $\mu\mu$ by the chlorophyll, and the radiation of this energy at infra-red frequencies; these latter are reabsorbed, resulting in the successive production of formaldehyde and carbohydrates. The ingenious experiments of Baly and his colleagues have provided us with a method of compassing the same end without the aid even of a catalyst by the application of ultraviolet light of short wave length ($\mu\mu = 200$). The freshly formed formaldehyde is further shown to have the power of absorbing ultraviolet rays of somewhat longer wavelength ($\mu\mu = 290$) and giving rise to polymerisation products like the reducing sugars, etc. Hence the ultraviolet light which will act on an aqueous solution of CO_2 to form carbohydrates must consist of two different wavelengths, a fact also confirmed by experiment by the authors.

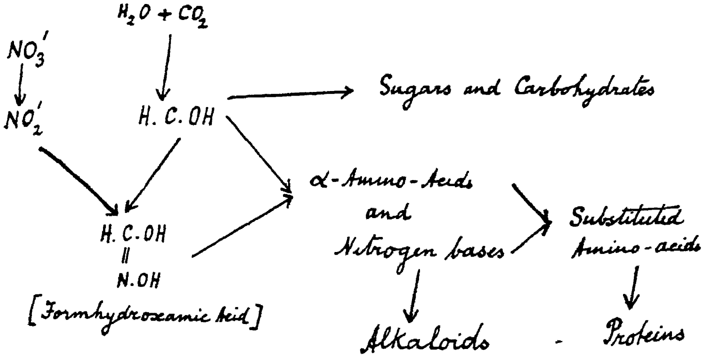
It is now generally agreed, therefore, that the conversion of CO_2 and water into formaldehyde which contains the trapped energy of the sunlight, marks the first step in the building up of all vital products,—the reaction *par excellence* "which forms the true key industry of all life."

I cannot help digressing a little and referring in this connection to the philosophical aspects of this photo-synthesis which were first emphasised upon by that daring and brilliant thinker, the late Benjamin Moore. While confirming and extending the results of Bach, Euler, Priestley and others, Moore proceeded further, and attempted to supply some stages that lie between anything ever so simple as the unicellular alga and the inorganic world. Tracing the origin of colloids to a state when Nature could not build up any more complex molecules, he asserts that "it was in the sea and in the lakes that life first originated by the bearing down of the sun's energy upon the inorganic colloidal complexities that were beginning to form there. These inorganic colloids not only form the organic matter but they build up into their own cells—they form skeletons for it. And so we can trace, if we commence at these beginnings, how Life began." Indeed, the difference between the organic and the inorganic worlds is by no means so fundamental as might at first sight appear. Even the forms of many of the smaller organisms—diatoms and radiolaria and some of the amoeba, betray a striking resemblance to many of the artificially, prepared natural silicates, and the new science of plasmology having for its object the study of the relation of mineral forms to the forms of living organisms, seems to have arrived at the conclusion that the form and structure of living things are largely due to the interplay of physical and chemical forces such as obtain in the inorganic world. Very significant, therefore, is the remark made by Moore that we shall never trace the beginning of life by studying bacteria, as these would not exist in the new world, having nothing to live upon. Moreover, sunlight is germicidal to bacteria, and hence various colour screens like chlorophyll, etc., had to be elaborated for protecting this dawning of life from being killed by the very sunlight which first originated it.

Formaldehyde, then, being supposed to be the initial product. the consideration of the subsequent stages in the process of carbon and nitrogen assimilation by the growing plant has given rise to the greatest controversy in recent times, and still remains to some extent a subject of speculation. There appears to be hardly any step by step process in this synthesis. CO_2 and water are absorbed by the green plant in sunlight and the first substances that can be isolated from the reaction products are the sugars, and the next ones, the highly complex colloidal bodies—the starches and celluloses. The whole series of consecutive reactions which must have intervened between the formaldehyde and the sugar seem to proceed with such extraordinary velocity that it has not been possible yet to follow them experimentally. Besides, there is clear evidence that asymmetric agents like the enzymes are concerned in bringing about many of these changes, as the sugars obtained in the plant are found to be optically active. The conversion of hexoses into disaccharoses and even higher complexes like the dextrins has been accomplished in the laboratory, and the formation of cellulose and its analogues may be reasonably considered therefore to be an extension of the same process, although no experimental proofs are available yet.

The synthesis of the proteins and even the enzymes and chlorophyll itself, perhaps, is of no less interest from this point of view. A plausible claim has been made out lately by Lipman and Taylor for the direct fixation of nitrogen from the air by the leaves of green plants; even if this were possible, it must occur to only a very limited extent, and we are therefore forced to consider the roots as the primary agents in nitrogen assimilation in plants, and the nitrates as the chief source of this element. The observation was made nearly forty years ago by the botanist Schimper that nitrites are always present in the living green leaf in the dark, but disappear in the presence of sunlight. That nitrates may be reduced to nitrites under conditions obtaining in plant tissues, particularly in the presence of a catalyst like iron, has now been definitely proved, and Baudisch made the very important discovery that a dilute aqueous solution of potassium nitrite containing methyl alcohol, when exposed to ultraviolet light, yielded small amounts of a highly reactive body identified with formhydroxamic acid.

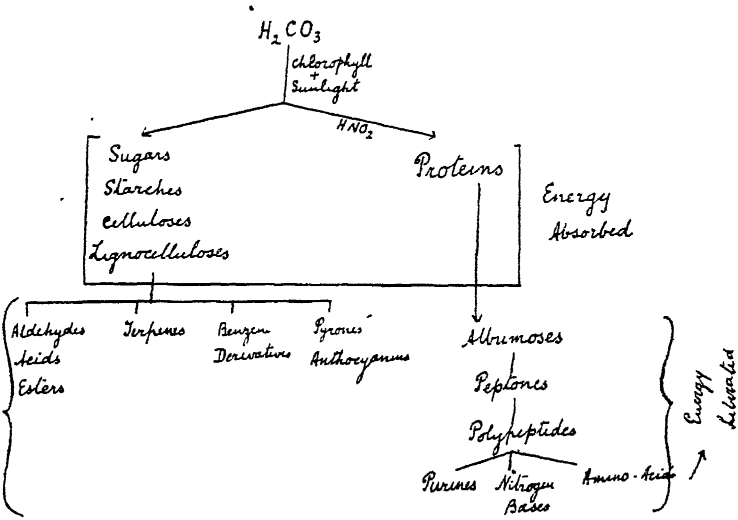
Combining these observations, Baly has developed his elaborate scheme, familiar to many of you, and supported to some extent by the remarkable experimental proofs adduced by him, in which the great variety of complex nitrogenous bodies actually found in the living plant are traced to the initial interaction between a nitrite and formaldehyde. The molecules of formhydroxamic acid so produced, as well as the formaldehyde, being supposed to be extraordinarily reactive when freshly synthesised, instantaneously react among themselves giving on the one hand α-amino-acids, and on the other, such nitrogen bases as pyrrols, glyoxalins and pyridines, which by further condensation give indoles, quinolines, isoquinolines and xanthine bases. The following scheme would thus indicate the main lines along which photosyntheses take place in plants:—



The scheme is based on the assumption that the reactions giving formhydroxamic acid precede the photocatalytic polymerisation of the aldehyde to sugars and other carbohydrates, the latter occurring only when the formaldehyde is produced at a rate greater than that at which it might react with the nitrite or the resulting formhydroxamic acid. Baly considers both the carbohydrates and the proteins as originating in the leaves as the result of the processes of photosynthesis indicated above, their subsequent distribution in other parts of the plant being effected in the form of soluble glucosides by the normal processes of translocation. There is considerable recent evidence, however, to show that the plant has the power of synthesising or perhaps re-synthesising a protein or a carbohydrate in the seed and other parts without the intervention of light. The action of ammonia or a simple amino body on the soluble sugars or on long chain carbon compounds derived from the sugars may be indicated as one of such probable methods of protein generation.

The recent observations regarding the occurrence of asparagine in plants and its probable function in the translocation of nitrogen from the leaf to other parts, and in protein metabolism in general, seem also to be of particular interest in this connection. The diminution of the protein contents of leaves, accompanied by the appearance of increased quantities of asparagin elsewhere in the plant noticed by several workers, has led to the suggestion that this substance acts as a temporary reserve for ammonia or amino-acids in a harmless and mobile condition suitable for transport from one part of the plant to another. The asparagin probably acts by regenerating ammonia which condenses with the α-hydroxy, or keto-acids obtained from the carbohydrates by enzymatic activity to form amino-acids, and thence, through the normal stages of polypeptides and proteoses, the molecule of the protein itself. This view of the function of the asparagin in the plant thus assigns to it a rôle which would seem to be somewhat similar to that of urea in the animal. The ammonia of protein metabolism, being toxic to the young plant above certain concentrations,. is rendered harmless by combination with aspartic acid, just as the ammonia of protein metabolism in the animal is rendered innocuous by conversion into urea. The analogy must not be pushed too far, however, as the asparagine must be considered as a storage material and not a waste product like urea.

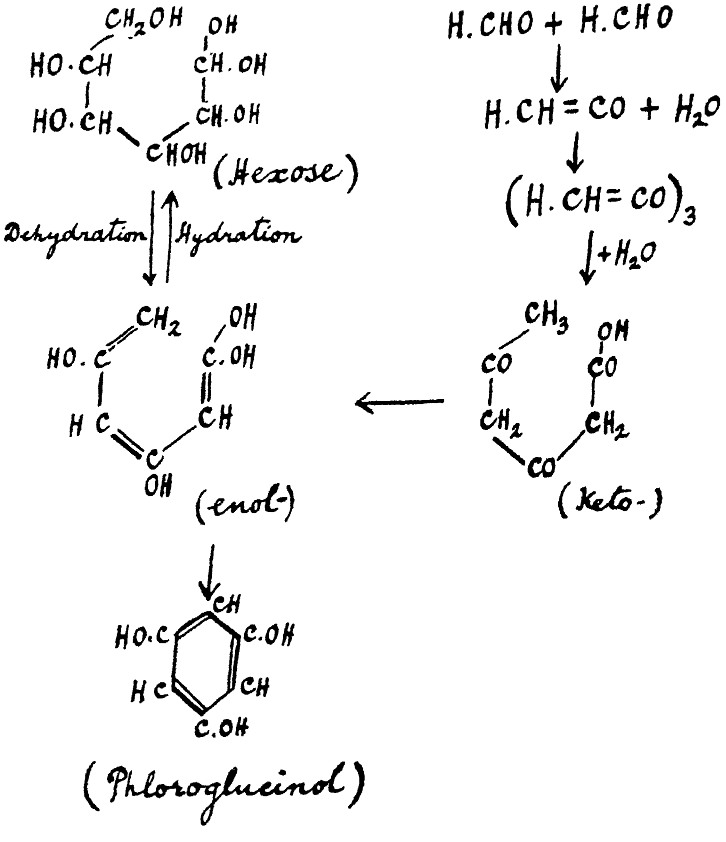
Whatever may be the correct view of the exact course of these syntheses in the plant—and it is doubtful if any single explanation can be found to cover all of them,—it may be unhesitatingly stated that the first substances that are formed and can be isolated as the result of the reactions between CO_2, water, and combined nitrogen are the sugars and the highly complex collodal bodies—the starches and proteins, whilst the vast majority of the other vital products such as fats, terpenes, alkaloids, colouring matters, to mention only a few, should be regarded as coming into existence at a later stage. Depending thus for the initial synthesis of complex molecules on the energy of the sun through the intervention of absorption screens and photocatalysts, our later experience of vital products obviously arises out of the chemical activity of the enzymes which cause the degeneration of the first formed complexes—a process attended with the liberation of the absorbed energy. These syntheses and degradations may thus be tentatively represented as below :—

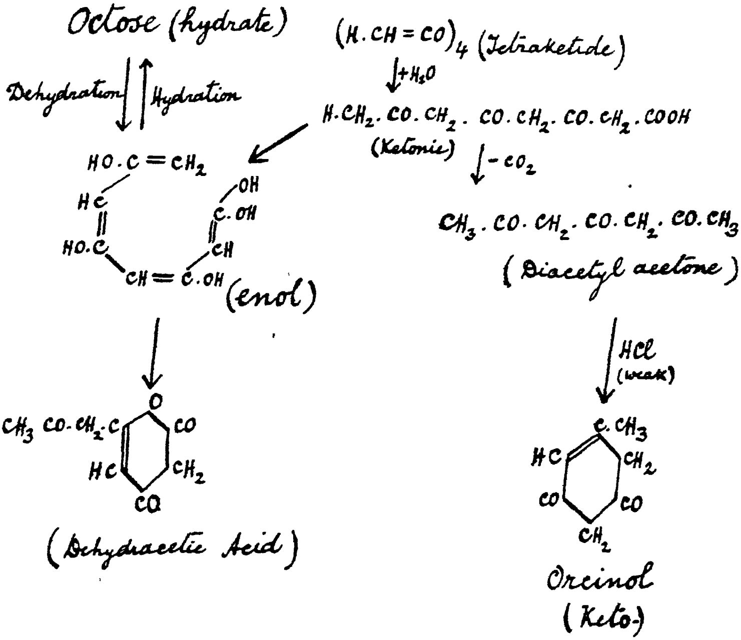


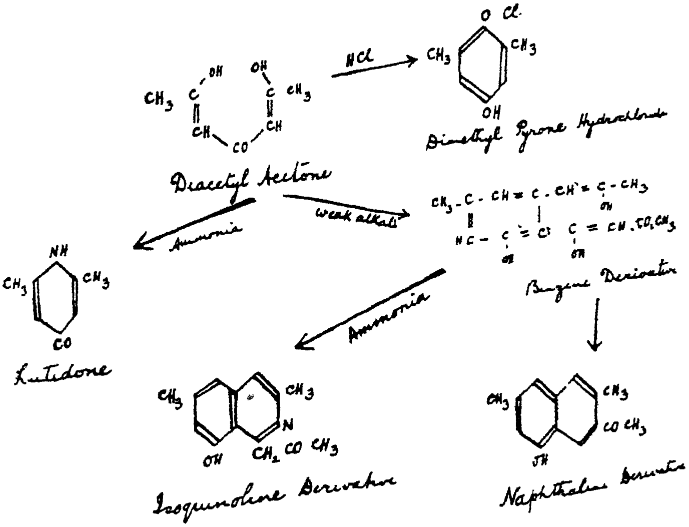
Two principal phases are thus distinguishable in the growth of every living organism—the period of elaboration of the complex colloids, apparently coinciding with that of active assimilation when the directive force is at its fullest intensity, and the other period in which the breakdown ensues and the system loses energy, corresponding to the phase in its life when the enzymes get the upper hand and the respiratory function predominates. It is conceivable, therefore, that the gain or loss of energy of all living organisms would ultimately depend on the preponderance of either the one or the other of these two processes.

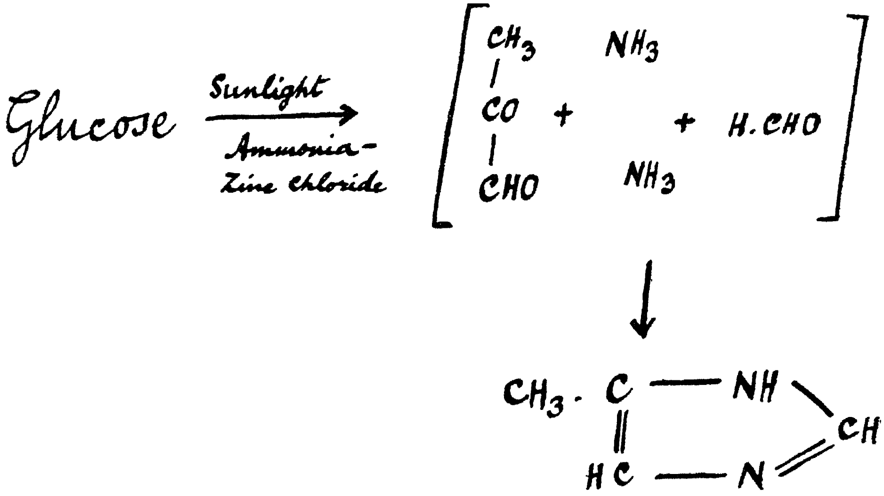
It would perhaps be unprofitable at this stage of our knowledge to draw up a more detailed scheme of degradation of the complex photosynthesised products than that outlined above, but I would only make a passing reference to two of the most attractive explanations of phytochemical processes that have been offered lately—the one proposed by Collie, in which the diverse products of plant metabolism like benzenes, pyrones, fats, terpenes, pyrrols, pyridines, anthocyanins and alkaloids, are all imagined to arise from a common origin, viz. chains of ketomethylene groups ($-CO-CH_2-$) produced either by the oxidation of carbohydrate chains or by the condensation of formaldehyde molecules to ketens followed by polymerisation, and the other developed by Robinson with reference to the synthesis of alkaloids based firstly, on his interesting and now familiar discovery that tropinone could be formed by the mere association of the di-aldehyde of succinic acid, methylamine, and a salt of acetone dicarboxylic acid in water without the assistance of a condensing agent or an increase of temperature, and secondly, on his investigations of the reactions between the higher amino-acids and formaldehyde.

The extreme fruitfulness of the ideas contained in these theories would be realised from a consideration of the following schemes:

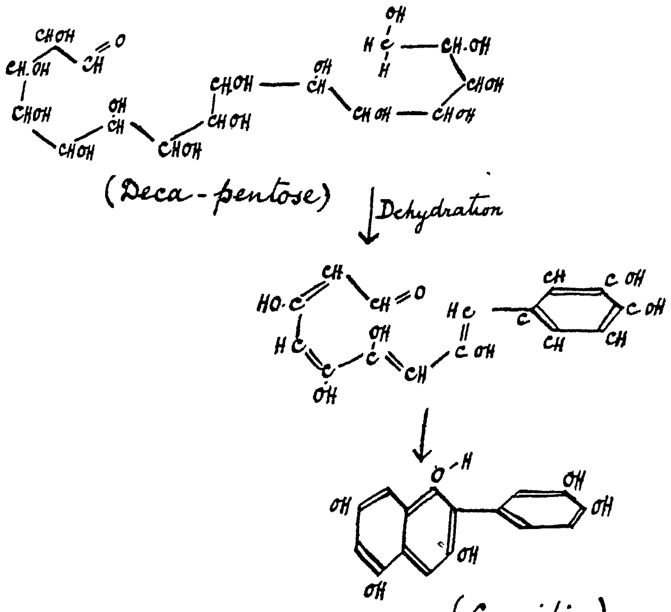



Octose (hydrate)
Dehydration
Hydration
(H.CH=CO)4 (Tetraketide)
+H2O
H.CH2.CO.CH2.CO.CH2.CO.CH2.COOH
(Ketonic)
-CO2
HO.C=CH2
HC
HO.C
CH=C.OH
OH
C.OH
CH
(enol)
CH3.CO.CH2.CO.CH2.CO.CH3
(Diacetyl acetone)
HCl
(weak)
O
CH3 CO.CH2.C
CO
HC
CH2
CO
(Dehydracetic Acid)
C.CH3
HC
CH2
CO
CO
CH2
Orcinol
(Keto-)


CH3
OH
OH
CH3
CH
CO
CH
Diacetyl Acetone
HCl
O Cl
CH3
CH3
OH
Dimethyl Pyrone Hydrochloride
weak alkali
CH3.C.CH=C.CH=C-CH3
HC-C=C C=CH.CO.CH3
OH
OH
Benzene Derivative
Ammonia
NH
CH3
CH3
CO
Lutidone
Ammonia
CH3
CH3
N
CH2 CO CH3
OH
Isoquinoline Derivative
CH3
CH3
CO CH3
OH
Naphthalene Derivative

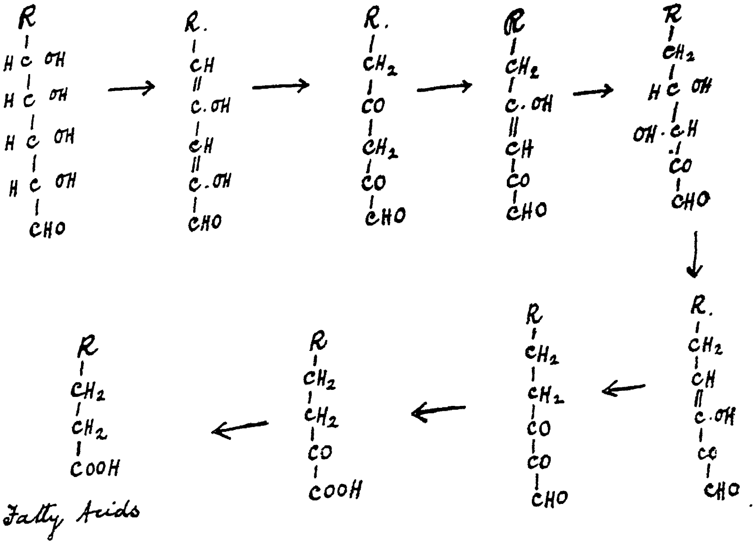


Methyl Iminazole

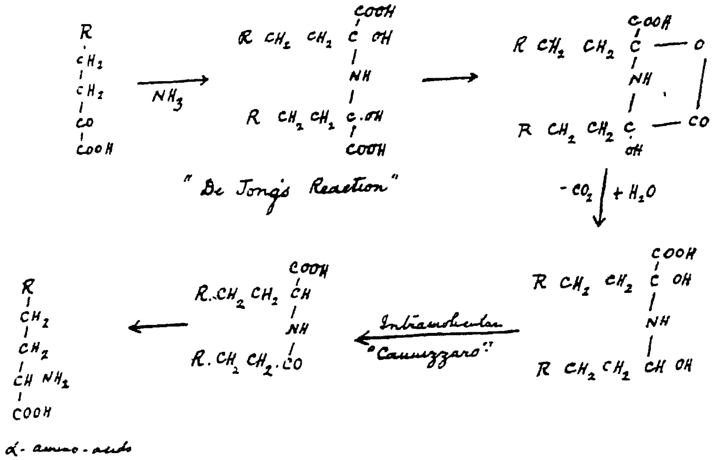


(Cyanidin)

The formation of fats and oils and the liberation of CO_2 during respiration may be explained in the following manner :—

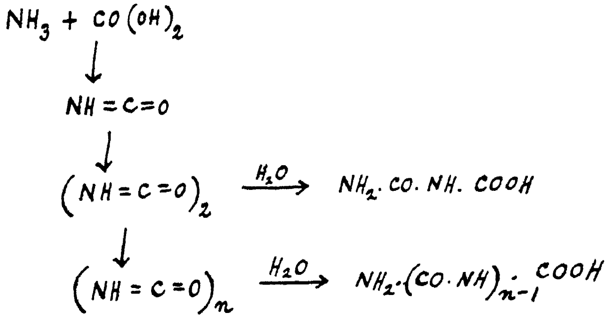


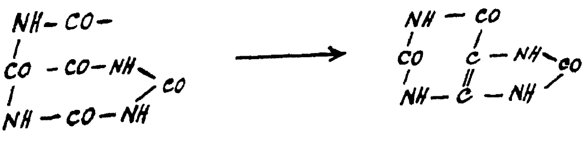
The result of such a series of reactions is the building of an aliphatic chain with methylene groups at one end and Co-groups at the other, loss of CO_2 from the latter end of the chain giving rise to the higher fatty acids, and thence the fats. Similarly the reverse process, that is, the conversion of fats into sugars, may be explained as arising from the conversion of the fatty acids into the polyketids and thence into the carbohy-



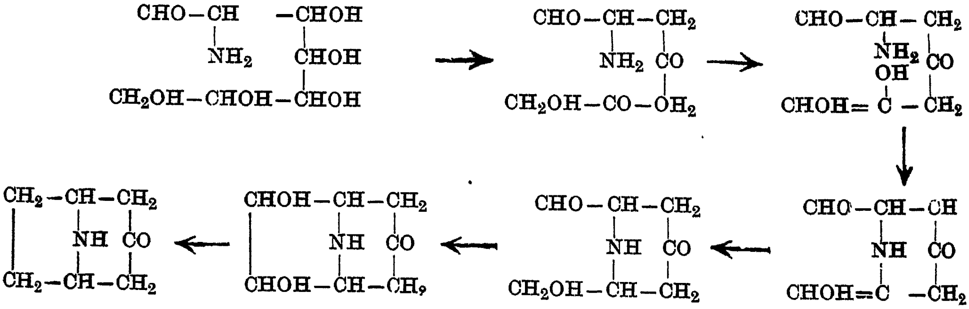
drates. Moreover, the same conception may be applied to explain the formation of the complex α-amino-acids starting from the carbohydrates, the suggestion being based on the observation made by De Jong that pyruvic acid and ammonia interact to produce alanine.

Another interesting speculation regarding the origin of the polypeptite chain and also of purine compounds is to consider its formation by the continued polymerisation of isocyanic acid molecules called by Collie "Azi-keten," which may be supposed to arise from the interaction of ammonia and carbonic acid. The suggestion is obvious that purine compounds may have also come into existence through such a type of polypetide chain by hydration followed by ring formation :—

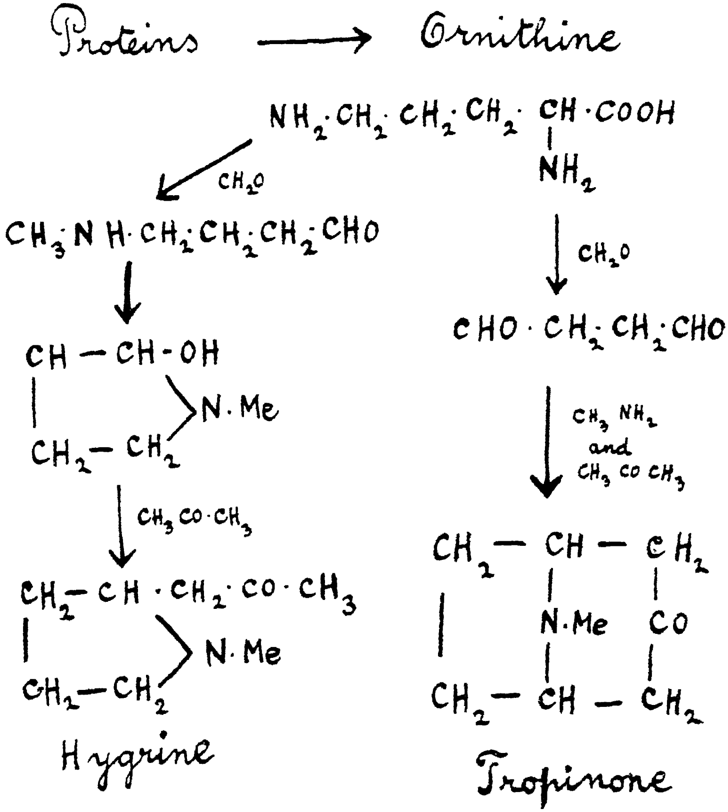


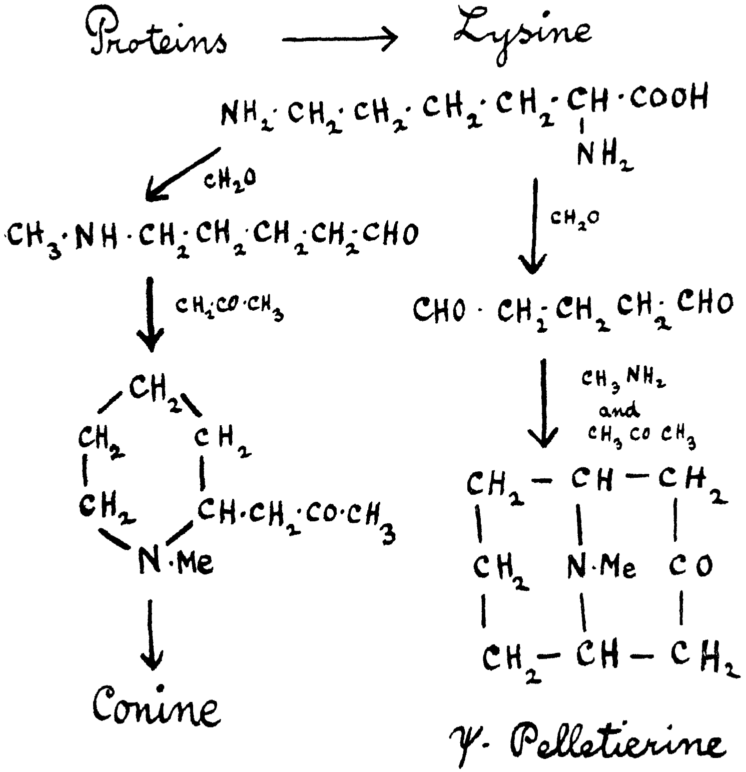


The same carbohydrate chain via the polyketides may also be shown to afford a source of alkaloidal materials, thus :—



Robinson's explanation of the formation of alkaloids from proteins would seem, however, to be more plausible, supported as it is by considerable experimental proofs. The following schemes illustrate the course of these changes which might result in the formation of some of the commonly known alkaloids:





Whilst these schemes have to be regarded for the present merely as suggestions, it is hardly necessary to emphasise their plausibility, accounting as they do for the formation of almost all the products found in living nature by means of such simple processes as oxidation, reduction, hydration, dehydration and polymerisation, all of which have now been shown to be within the powers of an enzyme to initiate or to accelerate.

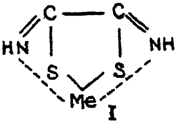
In concluding this brief and rather rambling survey of the present state of our knowledge of vital syntheses and the achievements of laboratory chemistry and its limitations, let me refer once more to the fact that the changes occurring in Nature whether they be through the agency of sunlight or enzymes, or both, are as yet the means of supplying humanity with its primal needs; that an understanding of the causes that operate in Nature for the production of food and drink, for bringing about the various metabolic changes, and if necessary their control, would constitute the crowning achievement of Man in his effort to live! Herein lies the need for carrying on greater and more assiduous investigations in that region between the so-called living and the non-living world, in order that we might approach the former with greater knowledge and confidence. Our hope lies in the already gained experience that this tract is not discontinuous, but that the gap hitherto believed unbridgable is slowly, though surely, filling up. "While men strive and fail and faint by the way, the work they have tried to do does not fail, but is eternally carried on in ways unknown to them."

Abstracts of Papers.

1. Metallic Compounds of Rubeanic Acid.—*By* P. R. Rây *and* R. M. Roy.

Sodium and Lead Salts of Rubeanic acid are mentioned in the Literature. In this paper a systematic investigation of other metallic derivatives has been undertaken.

Copper, Nickel, and Cobalt (—ous) are quantitatively precipitated from solutions of their salts by the addition of an alcoholic solution of Rubeanic acid or sym–dithio–oxamide, which reacts in its tautomeric form of sym-di-imido-dithio-oxalic acid towards these metals. Unlike the Sodium and Lead salts, the metallic atom in these compounds has been proved to be the centre of a cyclic co-ordination complex, as shown in the structural formula 1.



I

(Me=Metal atom).

The extreme insolubility of these compounds at once suggested the use of Rubeanic acid as an analytical reagent for copper, cobalt, and nickel. While Copper presented some difficulties, cobalt and nickel have been successfully estimated by precipitation of these metals as rubeanates.

The importance of Rubeanic acid as a reagent for the micro-detection of these three metals has also been demonstrated.

Mercury (—ic) is also completely precipitated from solutions of its salts, the product being an indefinite mixture of Rubeanic acid and HgCl—.

"Carbonato tetramino cobaltic nitrate gives tetra-aquo-diamino-tri-rubeanato-di-cobalt, CO_2 $(H_2O)_4$ $(NH_3)_4$ $(Rb)_3$, where $Rb=C_2$ H_2 N_2 S_2." The water molecules are lost by heating at 115."

2. Phototropic compounds of Mercury.—*By* S. V. Raghava Rao *and* H. E. Watson.

New compounds of the type Hg. X. CNR, in which X is a halogen and R oxygen or selenium, have been prepared. They all darken on exposure to light and revert to their original colour which is usually yellow on warming or prolonged standing in the dark. In no case is the colour change more rapid than it is with the corresponding compounds Hg. X. CNS previously described in which X is a halogen or the group SH.

The latter compounds have been studied in greater detail by coating glass plates with them with the help of gelatin and exposing them to light of different wave lengths in a spectroscope. Darkening is produced by a fairly wide band of light, that of wave length in the neighbourhood of 5000 A. U. being most active. Light of wave length 5500-6100 A. U. has no action, while light of longer wave length bleaches the compound when it has been previously blackened by exposure to light. The exact position of the neutral zone varies with the compound used.

3. Inorganic Phototropic Compounds.—*By* G. **Samba Murti.**

Three new phototropic compounds of lead, mercury, sulphur and two of the halogens in each, showing gradation, the one containing iodine and chlorine being the most phototropic and the one with bromine and chlorine the least.

4. The action of Silica on Alkaline-earth Sulphates at high Temperatures.—*By* L. A. **Bhatt** *and* H. E. **Watson.**

Calcium, strontium and barium sulphates when mixed with one molecular proportion of silica decompose to the extent of less than 1 per cent. in one hour at 900°C in air. Magnesium sulphate decomposes to the extent of 6 per cent. under similar conditions. At 1100°C magnesium sulphate is decomposed almost entirely and calcium, strontium and barium sulphates to the extent of 30, 2 and 5 per cent. respectively in one hour. Without silica, the decomposition is inappreciable except in the case of magnesium sulphate.

The action of silica upon calcium sulphate in presence of carbon has also been studied in order to find out what proportion of the sulphur it is possible to eliminate from the reaction mixture in the form of gas. Silica appears to inhibit the process of reduction and calcium sulphide is not readily acted upon by silica so that the yield of gas is diminished. The best results are obtained by heating calcium sulphate alone with two molecules of silica when almost complete decomposition results after four hours at 1100°C.

5. Extraction of Thorium Salts from Monazite.—*By* P. **Krishnamurti** *and* B. B. **Dey.**

A method for the extraction of pure Thoria from Monazite (Travancore), which dispenses with the tedious method of repeated fractionations with magnesia, and is also suitable for large scale operations, is described.

6. Hydrolysis of Ammonium Sulphide solutions.—*By* C. L. **Mankodi** *and* C. J. J. **Fox.**

The experimental investigation of the hydrolysis of ammonium sulphide solutions appears to have been neglected. The authors have now studied the hydrolysis by a method which is dynamic and which consists in the measurement of partial pressures of ammonia and hydrogen sulphide in ammonium sulphide solutions. A current of pure hydrogen was passed through ammonium sulphide solution; hydrogen removed free ammonia and free hydrogen sulphide from the solution and passed on into a conductivity vessel containing a solution of $\frac{N}{100}$ ($\frac{3}{4}$ $CuSO_4 + \frac{1}{4}H_2SO_4$); both ammonia and hydrogen sulphide were absorbed in this solution and the hydrogen then passed on into an ordinary syphon bottle and displaced water which was collected and weighed.

From the rise in the conductivity of the copper sulphate solution, due to the absorption of ammonia and hydrogen sulphide the amount of free hydrogen sulphide present in the ammonium sulphide solution was calculated. The amount of free ammonia in the ammonium sulphide solution was determined by estimating ammonia in the copper sulphate solution at the end of the experiment by means of a Tintometer.

From a knowledge of the initial total amounts of ammonia and hydrogen sulphide, free ammonia and free hydrogen sulphide, and amount of hydrogen passed, the hydrolysis constant K_{NH_4HS} and the degree of hydrolysis α_{NH_4HS} were calculated. The results obtained agreed fairly well with the values calculated on theoretical considerations.

The value of the first dissociation constant of hydrogen sulphide was also calculated from the above data and it agreed with the value obtained by previous workers.

7. The action of Sulphuretted Hydrogen on a Neutral Solution of Potassium Permanganate.—*By* HORACE B DUNNICLIFF *and* SUKH DAYAL.

The first products of the reaction between sulphuretted hydrogen and potassium permanganate in dilute solution appear to be (a) colloidal hydrated manganese dioxide which quickly coagulates into a gelatinous precipitate, (b) sulphur, (c) potassium sulphate and (d) potassium dithionate in solution. The reaction has been investigated quantitatively in stages.

When excess of sulphuretted hydrogen is passed through the solution the hydrated manganese dioxide is subsequently converted into manganous sulphide with the separation of sulphur. The manganous sulphide is first formed as a colloid which quickly coagulates into pink manganous sulphide. Excess of sulphuretted hydrogen decomposes the dithionate into potassium sulphate and thiosulphate with the simultaneous formation of sulphur. A portion of the sulphur is precipitated and the rest appears in the filtrate in the colloidal state and is completely precipitated on standing. The solution is alkaline throughout. This is probably due to the adsorption of the anions of the potassium salts by the hydrated manganese dioxide or sulphide.

8. Action of the Halogens on the Alkaline Earth Hydroxides.—*By* KISHEN LAL MALHOTRA, RAMA KRISHNA BAHL *and* H. B. DUNNICLIFF.

The action of a solution of iodine in carbon tetrachloride on calcium hydroxide showed that an adsorption compound is formed. $\frac{C_{ca(OH)_2}}{C^{\frac{1}{3}}_{ccl_4}}$ gave a constant value.

No action took place between iodine and Barium hydroxide.

In the case of action of iodine on Strontium hydroxide, $Sr(OH)_2 \cdot 8H_2O$, the iodine is first adsorbed and then chemical action takes place with the elimination of water. The final product of the reaction corresponds with either a mixture of strontium iodide and hypoiodite or a compound having the formula $\mathrm{Sr}{<}^{\mathrm{OI}}_{\mathrm{I}}$. In two out of three samples the ratios Sr : I : O were in the atomic proportions 1 : 2 : 1.

9. Reaction of Iodine and Bromine with Slaked Lime.—*By* M. DAMODARAN *and* W. ERLAM SMITH.

An investigation was made to see if iodine and bromine resemble chlorine in the formation of a compound analogous to bleaching powder The following conclusions were reached.

I. Iodine does not form a compound with slaked lime under the conditions examined.

II. Bromine yields a substance containing about 45% of available bromine at ordinary temperature and which retains 30% of bromine at 100°C. The product has a very close resemblance in properties to ordinary bleaching powder. It has not been possible to establish definitely whether the substance in question is a compound or only an adsorption product. The following facts are in favour of the view that a compound is formed.

(*a*) The high percentage of bromine present.
(*b*) The production of heat during the reaction.
(*c*) The complete analogy in properties with the chlorine compound. Against this it should be mentioned that the composition is not in conformity with any definite formula.

III. *Practical applications.*—Since the bromine product retains a fairly high percentage of available bromine even at 100°C, it has in respect of stability a distinct advantage over chlorine bleaching powder. It was, therefore, thought worth while to investigate the bactericidal action of the substance. Determinations according to the ordinary Rideal-Walker method have not been entirely satisfactory and the comparative intensities of the antiseptic action of the chlorine and bromine products are under investigation.

10. Action of air, free from water and carbon dioxide, on Bleaching Powder.—*By* A. N. MELDRUM *and* M. G. DESAI.

Solutions of bleaching powder were exhaustively studied by R. L. Taylor (Trans. C. S. 1910, 97, 2541.), air being passed through the solutions. He found that the escaping gas contained hypochlorous acid and chlorine and that the ratio $\frac{HClO}{Cl_2}$ gradually decreased.

The authors have passed air free from water and carbon dioxide over several samples of bleaching powder all prepared from the same sample of slaked lime.

In one series of experiments the issuing gas was passed into potassium iodide solution in order to distinguish between hypochlorous acid and chlorine. The equations are

$$2\ KI + Cl_2 = 2\ KCl + I_2$$
$$2\ KI + HClO = KCl + I_2 + KOH.$$

The amount of hypochlorous acid produced was very small and the bleaching powder evolved mainly water and chlorine.

In another series of experiments, the issuing gas was passed over phosphorus pentoxide to absorb water and over a mixture of mercury and mercurous chloride to absorb chlorine. The ratio $\frac{Cl_2}{H_2O}$ gradually diminished. It is paradoxical that the removal of water from bleaching powder is accompanied by evolution of chlorine. The equation

$$Ca(OH)_2 + Cl_2 \rightleftharpoons Ca < {OCl \atop Cl} + H_2O$$

suggests that the contrary should happen and that the removal of water should favour the absorption of chlorine.

This evolution of chlorine on drying bleaching powder depends upon the amount of available chlorine. It is not observed with samples assaying 30 per cent. or less.

11. Action of Mercury and its Salts on Aluminium Foil.—*By* S. S. BHATNAGAR *and* S. L. BHATIA.

Paul Nicolordot (Bull Soc. Chem., 1912, iv) and H. F. Hunt (J. Soc. Chem. Ind. 1896, 15) had previously observed that a dendritic growth is produced when an aluminium foil is coated either with mercury or its salts, and subsequently exposed to the atmosphere. The composition of the growth and the conditions governing its formation have, however, not been carefully studied.

In this paper both qualitative and quantitative analysis of the growths has been made and the role of mercury has thoroughly been elucidated. The following important conclusions have been arrived at by the authors :—

1. That the formation of the growth on Aluminium foil depends mainly upon mercury ions, and is only slightly affected by the anions.
2. That the formation of the growth is not only dependent upon mercury, moisture and oxygen, but also upon the presence of Co_2; no growth being formed when moisture and oxygen are completely freed from Co_2.
3. That the reaction is ionic in nature, growth being produced when Hg'' ions are present.
4. That the composition of the growths produced by mercury and its salts is the same, and the empirical formulæ deduced from them show that the growths consist of a hydrated oxide of Aluminium or more probably Aluminium Hydroxide.
5. It has also been observed that a similar growth is formed by Salts of Zinc.

12. The precipitation of Copper from Copper Sulphate Solution by Iron.—*By* M. B. RANE *and* T. R. NARAYANA PILLAI.

The precipitation of copper from its solution by iron is a phenomenon quite commonplace in the chemical laboratory, but the quantitative aspect of this phenomenon has not received the attention it deserves. The authors have not been able to find any data in the existing literature regarding the relationship between the amount of copper precipitated and the various other changing factors, such as the concentration of the copper sulphate solution, the surface of iron exposed, the length of exposure, effect of stirring, etc.

The present investigation is undertaken with a view to find out quantitatively the effect on the precipitation of copper produced by changing (1) the concentration of the copper sulphate solution, (2) the surface area of the iron wire and (3) the time of exposure of the iron wire. The influence of stirring and that of the addition of alkaloids to the copper sulphate solution has also been investigated.

Incidentally the question of whether or not an equivalent quantity of copper is precipitated by iron is also determined.

The results show that (1) there is a particular concentration of copper sulphate solution at which the maximum precipitation takes place, (2) stirring has a remarkable influence on the precipitation and (3) the alkaloids to a certain extent exercise an inhibiting effect.

13. The effect of the addition of Alkaloids on the rate of Solution of Iron in Dilute Hydrochloric Acid. Part II. The change in the E.M.F. produced in the iron by the addition of the Alkaloid Brucine.—*By* M. B. RANE.

In the paper read before the Congress last year and subsequently published in the Journal of Physical Chemistry (Rane and Mata Prasad J Ph. Ch. 249 March, 1925), the rate of solution of iron in hydrochloric acid was investigated and the quantitative study of the inhibition produced in the rate of solution by the addition of minute quantities of the alkaloids was made. These experiments have now been extended to other alkaloids and to some other substances. It was believed that the inhibition was due to poisonous substances alone, but it has been found since, that gelatine also exercises a similar inhibiting effect. No such inhibiting effect was found to be exercised by cane sugar, glucose, aniline hydrochloride, phenol, cresol, nitrobenzene, p -phenylene diamine. Results of experiments, showing the change in the E.M.F. produced in the hydrochloric acid and in N/1 ferrous sulphate by the presence of the alkaloids, are given in this paper. These results show that the E.M.F. is distinctly lowered by the presence of the alkaloids, showing that the condition of iron in the presence of the alkaloids is akin to the condition of passivity of iron produced by the usual passivifying agents.

14. Investigations on the nature of Solutions. 1. Preliminary note.—*By* D. D. KARVÉ.

Accurate measurements of the solubility of salts in different solvents, especially organic, and also the determinations of their molecular weights, electrical conductivity, absorption spectra and other physical properties will, it is hoped, throw some light on the condition of the solute molecules in the solutions. Measurements were made with solutions of different acetates in solvents like acetone and acetic acid, and conclusions drawn as to the nature of these solutions.

15. An apparatus for the determination of Vapour Pressures of Concentrated Solutions. *By*—K. S. NARGUND *and* H. E. WATSON.

An apparatus has been constructed in which vapour pressures of concentrated solutions may be measured by the static method at temperatures up to 50°C and the concentration varied without admitting air to the solutions.

The vapour pressures of solutions of sodium and magnesium chlorides have been measured.

16. The rate of Evaporation of Water from Surfaces of Metals and their Oxides.—*By* S. S. BHATNAGAR *and* S. L. BHATIA.

In this paper the rate of evaporation of adsorbed moisture from surfaces of iron, nickel, cobalt and their oxides has been studied. The apparatus used throughout the investigation has been the one devised by B. A. Keen. The experiments were carried out by exposing a known weight of the samples containing particles of a uniform size, soaking them for 24 hours and determining the losses in weight after intervals of half an hour. From the results thus obtained time curves have been plotted which show the order of evaporation to be

$$Fe > Ni > Co.$$

The same order holds good in the case of oxides. The curves are perfectly regular and consist in all cases of a single parabolic curve represented by the equation

$$X = At - Bt^2$$

where X=loss in weight.

T=time.

and A and B are two constants.

The values of the differentials $\frac{dx}{dt}$ have also been calculated and curves plotted, the points in all the six cases lie on straight lines. The order of the curves is the same as that of the Bohr's Magneton for these metals, but reverse as regards the Magnetic Susceptibilities.

17. The relation between surface tension and density.—*By* R. K. Sharma.

Various equations have been suggested about this relationship [cf. Macleod, *Trans*, Faraday Soc. 1923, 12, 38; Antonoff, Zeitsch. physikal. chem. 1924, 112, 461–66, and Lenschin, Zeitsch. physikal. chem. 1924, 112, 167-174].

None of these equations, however, are found to give satisfactory results in the case of associated compounds. The equations

$$\log P = M \log \lambda + C.$$

has been found by the author to hold both in the case ot unassociated and associated compounds, when P=density, λ=Surface tension, M is the slope, and C, the intercept.

18. Photochemical reaction between chromium tartarate and bromine in aqueous solution.—*By* J. C. Ghosh *and* A. N. Kappanna.

The photobromination of chromium tartarate appeared to be of peculiar interest, as it is one of the few coloured tartarates which can be obtained in a pure state and remains stable in solution. A 500 c.p. pointolite lamp with filters of Cuso$_4$ and KNo$_2$ gave only visible radiation of intensity 4000 ergs per sq. cm. per sec. A period of induction varying from three to five hours was observed at 26°C; and the reaction, after the maximum velocity has been reached, was always found to be unimolecular. The experimental data are given in table I.

Table I, T=26°c.

	Concentration of Bromine.	Velocity constants for various concentrations of chromium tartarate.				
	Conc. of Tartarate :—	·02M;	·04;	·06;	·08:	·1M
1.	·0342N ..	·00386;	·00664;	·00857;	·0104;	—
2.	·0484 „ ..	·00195;	·00405;	·00566;	·0066;	·0084
3.	·1010 „ ..	·00094;	·00113;	·00165;	·00193;	·00265
4.	·154 „ ..	·0008;	·00089;	·00102;	—	—

It will be noticed that with increase in the initial concentration of bromine, the velocity constants diminished, with increase in concentration of chromium tartarate for the same initial concentration of bromine, the velocity constants increased; applying Cario-Turner equation to data in horizontal column I, life period of active bromine molecule comes out to be 4.75 x 10-11 Sec. While data in columns 2 and 3 give life periods 2·1 x 10-11 Secs. and ·63 x 10-11 Secs. respectively. Thus with increase in the initial concentration of bromine, the life period of active bromine molecules diminishes. This parallelism in the diminution of life period of excited bromine molecules and the diminution of velocity constants, with increase in the initial concentration of bromine, is significant.

In another set of experiments, a filter of bromine solution was used, which gave red light of intensity 2700 ergs per sec per sq. cm. This light is presumably absorbed by chromium tartarate only. The results obtained with this light are given in Table 2.

Table 2.T=*33°c*

Concentration of Bromine.	Velocity constants for concentration of chromium tartarate :—			
	1%	3%	5%	10%
1. ·018N	·002243	·00429	—	—
2. ·026N	·001432	·00244	·00312	·007
3. ·035N	·00123	·001665	—	—
4. ·05N	·00087	·00118	—	—

Here too as in the previous case, and contrary to expectation, the velocity constants decreased with increase in the concentration of bromine. The results are not capable of interpretation according to accepted views of photochemical reaction.

19. On the Photochemical decomposition of some potassium Salts.—*By* K. Suryanarayana *and* J. C. Kameswara Rao.

A study of the wave lengths in the visible and the ultra-violet regions responsible for the decomposition of some potassium salts in aqueous solution is made and it is observed that these wave lengths occur in the absorption spectra of the solutions. It is however found that all the wave lengths in the absorption spectra do not affect equally the decomposition of the salts.

20. The Velocity of Esterification in Mixed Solvents.—*By* B. V. Bhide *and* H. E. Watson.

Experiments have been made on the velocity of esterification of suberic acid in mixtures of iso-amyl alcohol and benzene using hydrochloric acid as catalyst. It has been found that there is no very marked change in the velocity constant for mixtures containing less than 50 per cent. of benzene, but above this proportion a large increase takes place, the constant for a 90 per cent. solution being 15 times that for a 20 per cent. solution.

An even greater increase was found in the case of n-butyric acid dissolved in mixtures of iso-amyl alcohol and petrol.

21. Ethyl Hydrogen Sulphate.—*By* Abdul Hamid, Kirpal Singh *and* H. B. Dunnicliff.

It is shown that when sulphuric acid and ethyl alcohol are allowed to interact in equivalent proportions of 1 : 2, 1 : 1 and 2 : 1, the reaction is of the first order. The investigation was made at 0°C.

All attempts to prepare chemically pure ethyl hydrogen sulphate have failed. When very concentrated, the ester breaks down into a variety of products among which is free carbon,

Barium ethyl sulphate, Ba $(C_2H_5So_4)_2,2H_2o$, is dehydrated by alcohol giving Ba $(C_2H_5So_4)_2$ from which it separates in crystals.

The Solubility of ethyl hydrogen sulphate in dry ether containing small quantities of sulphuric acid has been determined at 30°C. It is found that, as the concentration of sulphuric acid rises from 0.10 to 0.54 per cent, the concentration of ethyl hydrogen sulphate falls from 1.1 to 0.5 per cent. The points determined lie practically on a straight line.

22. The System Sodium Sulphate—Sulphuric Acid-Ethyl Alcohol.—*By* H. B. DUNNICLIFF, INDER SAIN SIKKA *and* RATTAN CHAND HOON.

The equilibrium has been examined (*a*) by the action of dry alcohol on sodium hydrogen sulphate and (*b*) by the action of alcoholic sulphuric acids on sodium hydrogen sulphate.

The problem is complicated by the partial esterification of the sulphuric acid. The solid phases of the general formula xNa_2So_4, yH_2So_4 in equilibrium with the liquid phases containing sulphuric acid, ethyl hydrogen sulphate, water, alcohol and sodium sulphate (or its acid salts) have been determined at a temperature of 18.3—0.05°C.

23. The System—Ammonium Sulphate—Sulphuric Acid—Ethyl Alcohol.—*By* H. B. DUNNICLIFF *and* ARJUNA LAL AGGARWAL.

This system has been examined by the action of (*a*) alcohol on ammonium hydrogen sulphate and (*b*) by the action of alcoholic sulphuric acids on ammonium hydrogen sulphate. As in the case of the sodium salts, the problem is complicated by esterification. Hydrogen sulphates having the formulae $(NH_4)_2SO_4, H_2SO_4$; $2(NH_4)_2SO_4, H_2SO_4$; and $3(NH_4)_2SO_4, H_2SO_4$ have been identified and the composition of the liquid phases in equilibrium with each defined up to a concentration of 45% alcoholic sulphuric acid. Work between 45 and 65 % sulphuric acid is being repeated. When ammonium hydrogen sulphate is shaken with alcoholic sulphuric acids of 70 % sulphuric acid and over, the solid disappears.

24. Studies in ceric hydroxide Sol and Gel.—*By* B. K. VAIDYA *and* B. N. DESAI.

When an 11 p.c. solution of ceric ammonium nitrate is dialysed for 3 days, ceric hydroxide which is formed by hydrolysis sets to a soft yellow gel. If the dialysis is not carried to extreme, but an electrolyte added to the sol, then too ceric hydroxide forms a gel. This gel formation however does not take place if the electrolyte is added after heating the sol to 80°–90°C. From this behaviour the earlier investigators surmised that the sol had an emulsoid character before heating, but the particles could be dehydrated by heating the sol, when it changed from an emulsoid to a suspensoid. This change is now quantitatively followd by viscosity measurements.

Three types of measurements were carried out. (1) Viscosity during dialysis, (2) viscosity with change in concentration, before heating and after heating, and (3) viscosity of the dialysed sol after heating it to different temperatures. The results obtained in the first type show that the rate of hydration of the particles during dialysis in the first 10 hours is very great; in the next 35 hours the hydration is slower but fairly regular, while after 45 hours there is no more hydration. The second type of results give a typical "emulsoid" curve for the sol before being heated, but a "suspensoid" curve is obtained if the same sol is heated to about 90°C. The third type of measurements give the dehydration of the sol with temperature. Between 25°C and 50°C the rate of dehydration is very great but after 60°C it is considerably slow, till at 95°C there is complete dehydration. The sol then becomes a suspensoid.

The formation of the gel during dialysis was always found to depend on the amount of water taken from the outer liquid. The amount of water absorbed in this way was 1¼ times the bulk of the original sol. After this much absorption which is maximum the sol sets to a gel. The gel was found to work successfully as an ultrafilter. A thorium hydroxide sol of large particles could be successfully filtered through the gel, but the same sol having smaller particles passed out.

Freshly prepared gel when put in a desiccator gives out water very rapidly. After 6 days reddish brown lumps of ceric hydroxide remain behind which do not give out any more water. A drop of water put over these lumps crumbles them to powder with a cracking noise, changing the colour at the same time from brown to yellow.

The coagulation of the sol by electrolytes is being studied by means of a potassium photoelectric cell.

25. Studies in Silicic acid Gels during Setting. Part I. Dependence of time of Setting on the Concentration of Gel-forming Solution.—*By* MATA PRASAD *and* VINAYAK SHAMBHU KHALAP.

Bhatnagar and Mathur (Koll. Zeit. 30, 368, 1922) have pointed out that good Silicic Acid Gels are readily prepared when 12.5 per cent solution of Sodium silicate and 10 per cent solution of ammonium acetate are mixed together in equal volumes. To study the changes that take place in the mixture of the two solutions during the setting of the gel, the authors have examined the variations in the time of setting when equal volumes of different concentrations of the two solutions are mixed together. It has been found that the time of setting of gels prepared from a fixed solution of sodium silicate and increasing concentrations of ammonium acetate at first decreases, reaches a minimum and then increases. The minimum time of setting decreases as the concentration of sodium silicate solution is increased. The time, t, and c, ammonium acetate concentration curves consist of two parts both of which are parabolic in nature and can be represented by a general equation of the type

$$(t-\alpha c^{n})\ (t-\beta c^{-m})=o.$$

The decrease in the time of setting with increasing concentrations of ammonium acetate, is, of course, in conformity with the theories of coagulation. The increasing in the time with further increase of strength of ammonium acetate solution appears to be due to the stabilising action of hydrogen ions, on the silicic acid hydrosol.

On leaving the gels to dry, long crystal-like needles emerge from it which on analysis are found to consists of sodium acetate. The appearance of similar needles of sodium chloride obtained by Fells and Firth (J. Phys. Chem. 29, 241, 1925) on drying a gel prepared from sodium silicate and hydrochloric acid, shows that this phenomenon is inherently connected with the capillary structure of gels.

26. Coagulation of positive and negative Manganese Dioxide Sol.—*By* S. GHOSH.

The following generalisations have been made :—

(1) More of the electrolyte is necessary to coagulate a dilute sol than a stronger one.

(2) The amount of electrolytes necessary for coagulation are greater than their additive values, when the colloid is coagulated by a pair of electrolytes of varying valencies.

and (3) The phenomena of positive ' acclimatization ' are essentially connected and go hand in hand and are mainly due to the preferential adsorption of an ion carrying the same charge as the sol.

Experiments have been made with a negatively and positively charged manganese dioxide sol in order to test the applicability of the above generalisations. It is observed that negatively charged manganese dioxide is normal towards dilution, towards a mixture of electrolytes, and does not show the phenomenon of ' acclimatization ' appreciably. When, however, the sol is coagulated by such electrolytes like $CuCl_2$, $AgN0_3$, etc.. which possess highly adsorbed cations, the amount of electrolyte necessary to coagulate the sol is *less* when the addition is slow than when it is rapid. The positively charged manganese dioxide is normal towards electrolytes like KCl, K_2S0_4 etc., and is also normal when coagulated with a mixture of electrolytes like KCl and K_2S0_4, KNO_3 and K_2SO_4, etc. On the other hand this sol behaves abnormally towards dilution when coagulated with electrolytes like $AgN0_3$ $CuCl_2$ etc., and is also abnormal towards mixtures of electrolytes like $AgN0_3$ and $KN0_3$, $KN0_3$ and $CuCl_2$ etc. It is observed that positively charged sol shows positive acclimatization when coagulated with $AgN0_3$, $CuCl_2$ etc.

The results obtained here on the coagulation of positively and negatively charged manganese dioxide sol seem to prove the correctness of generalisations cited above.

27. Studies on the formation of Periodic Precipitation IV. The limit of peptisation of various sparingly soluble salt in different gels.—*By* A. C. CHATTERJI.

1. Experiments have been undertaken to determine the limit of peptisation of several sparingly soluble salts in different media, with a view to correlate the peptising influence of a gel on a particular salt and the formation of Liesegang Rings of that salt in that medium.

2. Peptising influence of 2% agar at 40°C and 3% gelatin at 29°C on the following substances has been studied :—

Silver Chloride, Silver Bromide, Silver Iodide, Silver and lead Chromates; and sulphides of lead, mercury and manganese.

Conditions under which Lead and Mercuric Iodides are precipitated in a 4·05% starch solution at 29°C have been also determined.

3. 3% gelatine exerts such a powerful influence (limit of peptisation being $2{,}929 \times 10^{-2}N$) that neither excess of K_2Cr0_4 nor $Pb(N0_3)_2$, the electrolytes used in generating lead chromate, can easily coagulate the sol; while, on the other hand, 2% agar-agar has a very poor peptising influence on Ag_2Cr0_4 (the limit of peptising being $9{,}802 \times 10^{-4}N$); and, in both the cases, it is very difficult to obtain rings.

4. The views expressed in an earlier paper (Koll, Ziet, 37. 97. 1925) about the peptising influence of a certain protective colloid on a particular sparingly soluble salt and possibility of the formation of rings of this salt in that medium, has been given an experimental basis.

Protective colloids exerting a mild peptising influence are best suited for the production of rings, those with a strong influence or almost none at all, both failing to give rings in them when used as a medium.

5. The nature of the charge on these colloids has also been determined, and in many cases the relation between the strength of the excess of the generating electrolytes necessary to bring about coagulation of the sol and the concentration of the coagulated colloid, has been established.

28. Evidence in favour of the existence of Ag_2CrO_4 in gelatin, in the colloidal condition :—Conductivity of Ag_2CrO_4 in gelatine.—*By* A. C. CHATTERJI *and* N. G. CHAKRAVARTI.

1. Williams and Mackenzie (J. C. S. 117,844,1920) came to the conclusion that Ag_2Cr0_4 produced by the addition of equivalent quantities of $AgNO_3$ and K_2CrO_4 in a gelatin solution exists in the ionic condition. This conclusion of theirs has not been supported by further work on the subject and it has been proved (Sen and Dhar, Koll. Zeit. 34,270, 1924, Dhar and Chatterji, Koll. Ziet. 37.1.1925) that when equivalent quantities of $AgNO_3$ and K_2CrO_4 are added to a gelatin solution, there is always an excess of CrO_4'' ions left in the solution, the Ag_2CrO_4 produced being in the colloidal condition

2. Experiments have been undertaken to find out the conductivity of

Ag_2CrO_4 in varying concentrations in gelatin solution at 35°C, the Ag_2CrO_4 being produced by the addition of equivalent quantities of $AgNO_3$ and K_2CrO_4.

Conductivity of equivalent concentration of $AgNO_3$ and K_2CrO_4 in gelatin under identical conditions has also been determined for each set of experiments.

3. It has been found from the experiments that the conductivity of Ag_2CrO_4 is much less than what it should have been if it were in the ionic condition. In some cases the conductivity of $Ag_2CrO_4 + KNO_3$ produced along with it is less than that of KNO_3 alone, which means that KNO_3 has been adsorbed by Ag_2CrO_4 in its course of formation thereby lowering the active concentration of KNO_3.

29. On Bradford's ion adsorption theory of Liesegang Rings.—*By* A. C. CHATTERJI.

1. It has been proved in previous papers that when we take small quantities of Ag_2CrO_4 there is no appreciable adsorption of the constituent ions by the precipitate in its course of formation.

2. The adsorption of Ag. ions, by generating much larger quantities of Ag_2CrO_4, has been studied.

3. The percentage of Ag. ions adsorbed was found to be in no case more than 10% of the excess. There seems to be no decrease in the amt. of the percentage adsorbed on decreasing the quantity of Ag_2CrO_4 within limits of these experiments.

4. The adsorption of CrO_4'' ions was determined by generating Ag_2CrO_4 by the addition of $AgNO_3$ to K_2CrO_4 so as to always leave an excess of K_2CrO_4. The percentage of CrO_4'' ions adsorbed is greater than that of Ag. ions, if the amt. of adsorbing precipitate is between 2 to 3 gm., but in cases where the quantity of Ag_2CrO_4 is less than 1,036 gm. there seems to be no appreciable adsorption which can be determined by the usual volumetric method employed for the estimation of CrO_4'' ions.

5. The percentage of adsorption in both the cases is greater from dilute solutions of the salts than in conc. ones, for the same quantity of the adsorbing precipitate.

6. From the experiments it is evident that the adsorption of ions in the formation of Ag_2CrO_4 Rings in gelatin cannot be so effective as hitherto claimed, especially on considering that the quantity of Ag_2CrO_4 in each ring is much less than 1,036 gm. which in itself is not sufficient to effect an adsorption, perceptible by the quantitative method employed.

30. Chemical Theory of Adsorption. Part IV. Adsorption of Potassium Permanganate and Dyes by fine precipitates.—*By* MATA PRASAD *and* VINAYAK SHAMBHU KHALAP.

Adsorption of Potassium Permanganate by zinc Oxide, Aluminium Oxide and Mangenese Dioxide in fine powders has been studied and efforts have been made to examine the nature of the adsorbed material. Qualitative tests indicate the presence of potassium and manganese ions in the powders after adsorption but no potassium permanganate is extractable by water or acetone. Manganese dioxide shows a great adsorptive affinity for potassium permanganate so much so that fairly concentrated solutions of Potassium Permanganate are decolourised by it.

The adsorption of dyes, by the insoluble precipitates of Barium Sulphate, Lead Chloride and Silver Chloride has also been studied. In all these cases the adsorbent is coloured with the colour of the dye which is easily recovered by treating the adsorbent containing the adsorbed material with either alcohol or acetic acid or hot water.

The attachment of the adsorbed material to the adsorbent is therefore chemical in nature, and varies with the nature of the two substances, being more rigid in the case of potassium permanganate than in the case of dyes.

31. Influence of non-electrolytes on the precipitation of Colloids by electrolytes and on the adsorption of ions.—*By* Kshitish Chandra Sen.

It is known that in presence of certain non-electrolytes the precipitation value of monovalent ions may even be decreased, whereas that of bivalent ions may be increased. Recently Weiser [J. Phys. Chem. 28, 1253 (1924)] has advanced an explanation on the assumption that the amount of adsorption of the coagulating ions may either be decreased or increased in appropriate cases thus showing the peculiar behaviour in coagulation experiments. When the amount of adsorption is increased in presence of the non-electrolyte the sol will be sensitised, and when the amount of adsorption is decreased, the sol will be stabilised towards the particular electrolyte. The following experiments were undertaken to test these views :—

1. The coagulation of manganese dioxide sol by copper sulphate and silver nitrate has been studied in presence of ethyl alcohol and cane sugar. It has been observed that cane-sugar greatly and alcohol to a less extent, stabilise the sol towards copper sulphate. In the case of silver nitrate however, sugar exerts no appreciable effect, whereas alcohol sensitises the sol.

2. The adsorption of copper sulphate and silver nitrate by hydrated manganese dioxide has been studied in presence of methyl and ethyl alcohols and cane-sugar. It is found that in every case the amount of adsorption is increased by the presence of the non-electrolytes.

3. It is shown that the conclusion of Weiser that adsorption of a non-electrolyte always decreases the adsorption of electrolytes is not tenable as a general case, and has been proved to be not true in the case of manganese dioxide.

4. Explanations of the effect of non-electrolytes on colloids are discussed and it is shown that the case presented in the present paper is anomalous and admits of no easy explanation. It is pointed out that the nature of the non-electrolyte must be of some importance in the stabilisation or sensitisation of sols towards electrolytes.

32. Interaction between hydrated Manganese Dioxide and Electrolytes in its relation to the Nature of Hydrolytic Adsorption.—*By* J. N. Mukherjee *and* B. N. Ghosh.

The interaction between hydrated manganese dioxide and electrolytes has been studied from the standpoint developed in a previous paper. The results confirm the conclusion that the usual chemical point of view is untenable and that the facts can be satisfactorily explained from our point of view. A sample of the substance having the composition 7·8 MnO_2, 2·4 MnO, 175 H_2O was found to contain only 0·00036 gram atoms of hydrogen replaceable by Potassium and Barium ions per gram of the substance. The substance thus contains 1 gram atom of replaceable hydrogen per 5·41 gram moles of MnO_2 and the same amount of replaceable hydrogen atoms per 7·09 gram atom of Mn and per 244 atoms of hydrogen present including water of hydration. There is a complete parallelism between the effect of different cations on the electrical charge on the surface and the concentration of hydrogen ions in equilibrium with them. Using the chlorides the order of cations obtained is $Ba > Sr > Mg > K > Na > Li$ which is identical with that of their electrical adsorbability as defined in a previous paper. Ba) Sr, and Mg reverse the charge of Manganese dioxide.

An interesting result which has an important bearing on the adsorption of ions is the form of the curve representing the effect of the concentration of $MgCl_2$ on the charge. The curve cannot be explained by assuming the independent adsorption of both ions, but can be satisfactorily accounted for from our conception of electrical adsorption. There is definite evidence of the primary adsorption of anions. In agreement with this observation the adsorption of acid by the substance has been observed.

33. Electro osmotic experiments with sparingly soluble acids and amines.—*By* J. N. MUKHERJEE *and* P. P. VENKATARAMA IYER.

Benzoic, cinnamic and salicylic acids etc. can adsorb primarily H^+, $S^=$ and OH-ions. They show a negative charge in alkaline solution and a positive charge in acid solution. Solutions of neutral salts have very little effect on the charge, which seems to indicate the anhydrous adsorption of H^+ ions. The negative charge in alkaline solution may be ascribed to the interaction of OH ions with the surface or more correctly to the adsorption of anion of the acid present in the alkaline solution. The results of these experiments can also be interpreted as an example of the adsorption of constituent ions by a crystalline solid. Results obtained with insoluble amines are more complicated. Further experiments are in progress.

34. On a new method of verifying Smoluchowski's theory of coagulation of colloids.—*By* J. C. KAMESWARA RAO *and* K. SURYANARAYANA.

The method consists in studying the state of polarisation of the light scattered by the colloidal solutions after adding the coagulating agent.

35. Coagulation and adsorption by vanadium pentoxide sol.—*By* DHIRENDRA NATH CHAKRAVARTI.

Experiments have been made with a sol of vanadium pentoxide prepared according to Biltz's method to verify Ghosh and Dhar's generalisation about (*i*) dilution effect (*ii*) coagulation by a mixture of electrolytes and (*iii*) the phenomenon of acclimatization. It has been observed that vanadium pentoxide sol behaves normally towards dilution, towards a mixture of electrolytes and does not show the phenomenon of acclimatization appreciably.

Vanadium pentoxide sol is a very good absorbent and mainly adsorbs the basic portion of the added electrolyte. This is attributed to the acidic character of the sol.

36. Shulze-Hardy law and Adsorption.—*By* N. R. DHAR *and* S. GHOSH.

1. The generally accepted view that an ion, which is highly adsorbed also possesses a high coagulating power is not supported by experiments on adsorption.

2. There is no justification for the assumption that the greater the valency and hence the coagulating power of an ion the greater is its adsorption.

3. On the other hand, experiments on the coagulation and adsorption of different ions by the sols of HgS, Sb_2S_3, Al $(OH)_3$, Fe $(OH)_3$, MnO_2 etc., strongly support our view that the greater the valency of an ion the less is its amount of adsorption and smaller the coagulating power of an ion the greater is its amount of adsorption.

4. It has been shown that the large amount of adsorption of ions associated with the coagulation of sols like MnO_2, Fe $(OH)_3$, Al $(OH)_3$,

Cr $(OH)_3$, is mainly due to a marked chemical affinity of these substances for different ions.

5. It seems very likely that the valency of an ion is a more important factor in coagulation than its adsorbability.

37. On the continuity of the Electric Structure of the colloidal particle, the ion, the electron and the sub-electron.—*By* S. Ray.

From Yu Chen Yang's experiments in Zurich it can be shown that for ultramicroscopic particles, that have been given the "Saturation charge" by illuminating with ultraviolet light, $\frac{e}{a}$ is a constant, where e denotes the electric charge on the particle and a its radius. In connection with this result attention is drawn 1) to the constancy of $\frac{e}{a}$ for colloidal particles as well as 2) to a proof given by Smoluchowski of the ionic charge being only a 'limiting case' of the "cataphoretic charge."

38. Habits of Crystals.—*By* S. S. Bhatnagar, R. S. Seth *and* R. S. Gupta.

In studying the crystalline forms of matter we meet with certain habits of crystals that are not explained on the basis of the present classification. For example, calcite has two distinct varieties of crystals having absolutely the same chemical properties. Again facets of crystals of the same substance are never proportionate in size. The authors of this paper believe that physical conditions and external forces have an appreciable influence on the symmetrical shaping of the crystal.

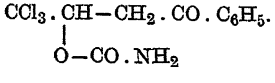
In this paper were tried the effects of supersaturation and viscosities of the media in which the crystals were allowed to grow. Volumes of the developed crystals increased with supersaturation till at a particular stage side-crystallisation began. The volume then decreased gradually. With the increase in viscosity (concentration remaining constant) the crystals developed greater volumes. It appears that the growth of crystals is hindered by the proximity of the side nuclei which are formed at a higher stage in super-saturation due to excessive packing and consequent mutual attraction amongst the molecules. Viscosity hinders the rapid movement of the molecules and thus prevents the appearance of foreign nuclei. It helps therefore the regular growth of the crystal.

It was also observed in the case of copper sulphate that the facets "a," and "a_1" of the crystals developed in a plane perpendicular to the thread suspending the nucleus. It appears therefore that the forces responsible for the regular growth of the crystals have a directional significance and are probably influenced even by the force of gravity. To suppport this, it was noticed in the case of Potash Alum that the rectangular facets between the triangular ones lie on a cylindrical plane only.

The work on the effects of Magnetic field, Electric field, Ultraviolet light, Polarized light etc., is in progress.

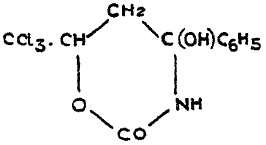
39. Pseudo urethanes.—*By* Hemendra Kumar Sen *and* Chittaranjon Barah.

Chloralacetophenone $CCl_3CH(OH).CH_2.CO.C_6H_5$ when treated with chloroformamide $ClCONH_2$ in dry ethereal solution, yields a derivative having the same chemical composition as the expected urethane



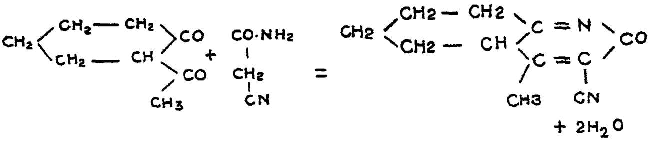
$$\underset{\displaystyle O-CO.NH_2}{CCl_3.\overset{}{CH}}-CH_2.CO.C_6H_5.$$

On trying to crystallise it from boiling alcohol, the product obtained showed an indifferent melting point which became stationary at 102°C when the initial product was boiled for about an hour with absolute alcohol. This was considered at first to be a metaoxazine as the grouping would justify such an expectation, but on analysis it was found to be trichlorethylidene acetophenone which must have been produced from the urethane by the splitting up of the formamide group and subsequent dehydration. But on trying to prepare a benzylidene diurethane of the supposed urethane. the result was in the negative, although urethanes of primary, secondary and tertiary alcohols respond to this test; nor did chloralacetophenone yield the allophanic ester with excess of chloroformamide. The conjecture, therefore, is that the supposed urethane is really a metaoxazine, having an aldolphase—



40. Condensation of Acetyl cyclohexanones with cyanoacetamide.—*By* HEMENDRA KUMAR SEN *and* UMAPROSANNA BOSE.

Equimolecular proportions of acetyl cyclohexanones and cyanoacetamide dissolved in alcohol, when treated with a few drops of diethylamine or piperidine, yield heterocyclic compounds in a few minutes, the separation of the sparingly soluble condensation product being complete in about two hours at 60°C.

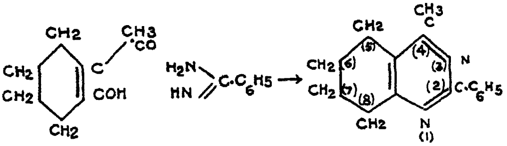


Similar condensation products have been obtained with ortho-, meta-, and para-methyl acetyl cyclohexanones. Their hydrolysis has been effected by heating with strong hydrochloric acid in sealed tubes at 150–160°C, giving rise to reduced carbostyril derivatives which impart deep red colouration to alcoholic ferric chloride solution. No evidence has been obtained yet of their being mixtures, from which it would appear that the reaction starts either from the Keto-group of the acetyl or from the Co-group of the cycloketone. The former is more likely, as the ketonic group next to the primary carbon is usually more reactive. Experiments are in progress to reduce these derivatives to quinoline so as satisfactorily to establish their constitution. These condensation products lend themselves to easy methylation and ethylation.

41. On *bz*-tetrahydro-quinazolines.—*By* PRAFULLA CHANDRA MITTER *and* ASHUTOSH BHATTACHARYA.

Amidines condense with acetyl-cyclohexanone giving rise to *bz*-tetrahydro-quinazolines of which very few representatives are known in literature.

We have investigated the action of Benzamidine and *p*-tolenyl amidine on acetyl cyclohexanone and the acetyl methyl cyclohexanones, and have obtained in this manner a large number of *bz*-tetrahydro-quinazolines :—



(1) Benzamidine and acetyl cyclohexanone-2-phenyl-4-methyl-*bz*-tetrahydro-quinazoline. Light feathery crystals from dil. alcohol. M.P. 103°C.

(2) *p*-tolenyl-amidine and acetyl cyclohexanone 2-*p*-tolyl-4. Methyl-*bz*-tetrahydro-quinazoline. Light feathery crystals from dil. alcohol. M.P. 129°-130°C.

(3) Benzamidine and 2-methyl-6-acetyl cyclohexanone :—
2-phenyl-4-8-dimethyl-*bz*-tetrahydroquinazoline. Feathery crystals. M.P. 84°-85°C.

(4) *p*-tolenyl amidine and 2-methyl-6-acetyl cyclohexanone 2-*p*-tolyl-4-8-dimethyl-*bz*-tetrahydroquinazoline. M.P. 95°C.

(5) Benzamidine and 3-methyl-6-acetyl cyclohexanone : —
2-phenyl-4-7-dimethyl-*bz*-tetrahydro-quinazoline. M.P. 111°-112°C.

(6) *p*-tolenyl amidine and 3-methyl-6 acetyl cyclohexanone-2-*p*-tolyl-4-7-dimethyl-*bz*-tetrahydro-quininzoline. M.P. 125°-127°C.

Detailed study of the properties of these and other compounds of this series is in progress.

42. Action of alkali and sodium sulphite on Quinolino-6 : 5-α-pyrones 6. hydroxy-quinoline-5-β-acrylic acids.—*By* T. R. SESHADRI *and* B. B. DEY.

Quinolino-pyrones when hydrolysed with aqueous alkali form unstable cis-hydroxy-quinoline acrylic acids. The conversion to the trans compounds can be effected only by the combined action of sodium sulphite and caustic potash. These acids are stable substances and on heating decompose, like the trans acids from other pyrones, into CO_2 with the formation of styrene derivatives. Their esters however possess the extraordinary property of eliminating alcohol at their melting points and closing up the ring. There are undoubtedly cases on record where halogens and halogen acids are removed from trans positions and this elimination of alcohol from the trans ester may be regarded as one of the same type. It is to be noted however that such a difference in behaviour between the acids and their esters is remarkable and without any parallel so far as we have been able to ascertain.

43. Activity of the methylene group in coumarin-4-acetic acids, Part III. Condensation of 7, methyl coumarin acetic acid with hydroxy benzaldehydes.—*By* T. R. SESHADRI *and* B. B. DEY.

In continuation of the work communicated last year, the condensation of para- and meta-oxy benzaldehydes with 7, methyl coumarin-4-acetic-acid has been studied. The mechanism of the peculiar colour changes of these products in solution has been already outlined in the abstracts of 1925. The view expressed before, that the production of the deep red colour and its subsequent fading is due to the formation of the quinonoid molecule followed by the opening up of the pyrone has been substantiated by (1) the replacement of the phenolic hydroxyl with acetyl and methyl groups and the examination of the behaviour of the resulting acetyl and ether derivatives, and (2) the analysis of the silver salt obtained from the colourless coumarinic acid produced.

44. Coumaryl isocyanates, isothiocyanates and their derivatives.—*By* T. R. SESHADRI *and* B. B. DEY.

Coumaryl isocyanate is a crystalline solid obtained by the action of carbonyl chloride on 6, amino-coumarin. It condenses in the usual way with amino and hydroxy bodies to form coumaryl ureas and urethanes. Both mono-coumaryl and phenyl-coumaryl ureas decompose at their melting points to form dicoumaryl and diphenyl ureas. The behaviour of aniline with coumaryl-urethane is noteworthy; with only a molecular proportion of aniline and a temperature above 200°C dicoumaryl urea is produced, whereas, with a large excess of aniline and a lower temperature no dicoumaryl urea is formed, but diphenyl urea only is obtained pure after repeated crystallisation.

Symmetrical-dicoumaryl-thio urea which is obtained by the action of carbon-disulphide on 6, amino coumarin is not hydrolysed by concentrated sulphuric or hydrochloric acids or by boiling acetyl-chloride even. It is however readily split up by acetic anhydride to yield the isothiocyanate. The mustard oil has also been prepared in a quantitative yield by the direct action of thio-phosgene on amino-coumarin. It combines in the usual manner with amino-bodies to form thio-ureas and with absolute alcohol to produce coumaryl-thio-urethane. The mono-coumaryl and phenyl-coumaryl-thio-ureas resemble the coumaryl ureas in decomposing at their melting points.

45. Nitration of coumarin.—*By* P. KRISHNAMURTI *and* B. B. DEY.

The impure residues obtained during the nitration of coumarin by Morgan's method yielded, after several crystallisations from acetic acid, a product melting sharply at 141°C, and giving the analytical figures for a mono-nitro-derivative. It was found to be a mixture in almost equal proportions of 6, and 8 nitro-coumarins which were separated by making use of the difference in the stability of their respective coumarinic acids. The sharp melting point of an equimolecular mixture of two different nitro-coumarins seems to be noteworthy.

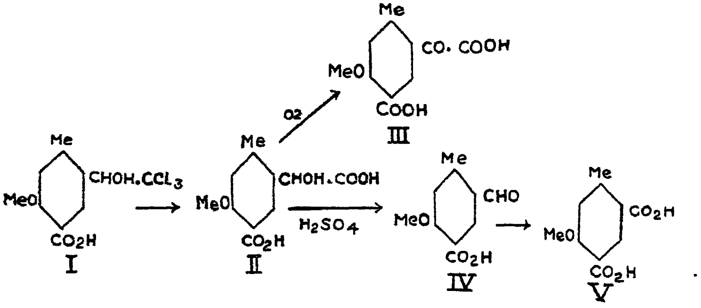
46. Condensation of Benzoylacetonitrile with aromatic aldehydes.—*By* P. KRISHNAMURTI *and* B. B. DEY.

Benzoylacetonitrile condensed in the usual manner with vanillin, *p*-hydroxy-benzaldehyde, *p*-dimethylamino-benzaldehyde, anisaldehyde, salicylaldehyde methyl ether, etc. O-aminobenzaldehyde gave a quantitative yield of 2, phenyl-3, cyano-quinoline, whilst salicylaldehyde gave a small yield of 3, benzoyl-coumarin. In the case of salicylaldehyde, the interesting observation was made that on employing a slight excess of piperidine which was the condensing agent used in the above reactions, the benzoylacetonitrile condensed with the piperidine itself to form a basic substance of the formula, $C_{14}H_{16}N_2$, the salicylaldehyde appearing to act as a catalyst. 5, bromo-salicylaldehyde also promoted the reaction, but not salicylaldehyde methyl ether. A similar basic product was also obtained by condensing benzoylacetonitrile with aniline in the presence of salicylaldehyde.

47. A synthesis of α-Coccinic Acid.—*By* A. N. MELDRUM *and* R. L. ALIMCHANDANI.

The condensation of chloral with *m* cresotic acid was found to give rise to a complex mixture of substances. It was therefore decided to condense chloral with the methyl ether of *m* cresotic acid. The main product of the reaction (I) was hydrolysed, when it gave a substituted lactic acid (II), which was (i) oxidised to a substituted pyruvic acid (III), and (ii) by treatment with sulphuric acid, converted into the aldehyde (IV) which was oxidised to the methyl ether of α-coccinic acid (V).

The constitution of these substances was ascertained as follows: α-coccinic acid was prepared from ethyl acetoacetate and chloro-form (Oppenheim and Pfaff, Ber. 1875, *8*, 884) and was found to be identical with the acid obtained by hydrolysing the substance (V) The same coccinic acid was methylated and was found to be identical with the substance (V.).



48. The reduction of the group—CH(OH)-CCl$_3$, Part II. —*By* A. N. MELDRUM *and* M. G. BHOJRAJ.

In continuation of the work of Meldrum and Alimchandani (Q.J.I.C. Soc., 1925, 2, 1–9) on the reduction of the group—CHOH-CCl$_3$ to -CH$_2$.CHCl$_2$, the authors have carried out the same change in the case of chloral derivatives (1) of the amides: provisional formula

$$R\text{-}CO.NH.CHOH.CCl_3$$

and (2) of acetophenone:

$$C_6H_5.CO.CH_2\text{-}CHOH.CCl_3.$$

49. Isomeric Phenylserines.—*By* M. O. FORSTER *and* M. K. ASWATH NARAIN RAO.

The phenylserine prepared by Erlenmeyer Junr. was stated by him to melt at 196°C. His method of preparation is difficult to follow, but by a suitable modification we have obtained the same substance melting at 200–202°C. The phenylserine already described by us as arising on reduction of the corresponding phenyltriazohydroxypropionic acid melts at 230–232°C, and is identical with the amino-acid from cinnamic acid chlorohydrin and concentrated ammonia. We regard these two isomerides as racemoids in one of which (m.p. 230–232°C) the hydroxy-and amino-groups have the *cis*-configuration, whereas in Erlenmeyer's modification (m.p. 200–202°C) they have the *trans*-configuration. The principal evidence for this view lies in the fact that benzoylation converts the *cis*-form into a colourless benzoyl derivative (m.p. 197°C), whilst the *trans*-modification undergoes simultaneous dehydration, yielding the yellow benzoylaminocinnamic acid lactimide (m.p. 164°C).

An attempt to prepare from phenylserine ethyl ester hydrochloride, by action of ammonia, the diketopiperazine corresponding to picrorocellin led only to the amide of *cis*-phenylserine (m.p. 199–200°C).

50 Oxidation of Mono-Hydroxy Abietic acid. Preparation of Trihydroxy and dihydroxy Abietic acids.—*By* MADYAR GOPAL RAO.

This is a continuation of the research on the Abietic acid from the rosin of *Pinus longifolia* (Rau and Simonsen, Indian Forest Records, Vol. XI, part 6) and describes new derivatives of Abietic acid namely Dihydroxy Abietic acid M.P. 278°C, its methylester M.P. 144°C, acetyl derivative M.P. 186°C and Trihydroxy Abietic acid M.P. 215°C and its methy ester M.P. 172°C.

51. Molecular re-arrangement during bromination.—*By* M G. SRINIVASA RAO *and* C. SRIKANTIAH.

1. 4-nitro resorcinol-1-methyl ether obtained as a bye-product during the nitration of 4-methoxy β-resorcylic aldehyde, has been brominated and one of the products is found to give long deep yellow needles, M.P. 126°-7°C.

2. The dibrom derivative of the same aldehyde (see the other paper) on nitration gives a yellow solid also melting at 126°-7°C and found to be identical with 1 above.

3. 5-nitro 4-methoxy β-resorcylic aldehyde, in which the NO_2 is in a different position, when brominated in the same manner, also gives a deep yellow solid, M.P., 127°-8°C, indicating ortho-nitro-phenolic structure.

The nitro-dibrom products in all the three cases were further found to be identical by a preparation of their dimethyl ethers, which all melted at 81°-82°C, individually as well as mixed.

Since 4-nitro resorcinol 1-methyl ether and 5-nitro 4-methoxy β-resorcylic aldehyde so different in structure, the one being an ortho- and the other a para-nitro phenol, yield the same product on bromination, it is concluded that a molecular re-arrangement has taken place during bromination of the one or the other.

A number of experiments and arguments have been advanced to explain how the results may be interpreted, whether a methoxy- or a nitro-group could have wandered during such bromination.

52. Substitution in Resorcinol derivatives. Part III. Bromination of aldehydes of the the above series.—*By* M. G. SRINIVASA RAO *and* M. SESHA IYENGAR.

It has been stated that 4-methoxy-β-resorcyl aldehyde and some of its derivatives are sensitive to the halogen acids except HF (Rao, etc., J. 1925,127–559) yielding amorphous coloured substances. The bromination of such aldehydes has been carried out in a way that free HBr is not present in any large quantities to affect the aldehyde.

(1) In different media and adopting different methods for the removal of HBr formed, we have obtained a Mono and di-brom derivative but as yet neither the tri-brom derivative containing the CHO nor 2-4-6 tri-brom resorcinol-3 methyl ether has been obtained during the course of bromination.

(2) It has been further shown that the Mono-brom derivative could be brominated to yield the di-brom and that the latter when nitrated yields

(D), 2·6 dibrom-4-nitro-resorcinol-1-methyl ether, M.P. 126-7°C, not obtained before, which on subsequent methylation yields (E), 2-6-dibrom, 4-nitro resorcinol dimethyl ether, M.P. 81-82°C, which has been obtained by Jackson and Fiske (Am. 30, 57–70).

(3) From the foregoing it has been concluded that the mono- and dibrom products are 5- and 5-3 aldehydes and that the latter (B), when nitrated, yields a nitro derivative, where the NO_2 has replaced the aldehyde group, which was ortho- to the free phenolic group.

(4) Existing literature shows that the NO_2 group during nitration often replaces the aldehyde and we have also obtained in yields of over 10%, 4-nitro resorcinol-1-methyl ether, when nitrating 4-methoxy β-resorcylic aldehyde.

Dahmer (A. 333–360) has stated that when poly-brom substituted phenols are nitrated the NO_2 group usually substitutes either a H or Br ortho to the phenolic group, but that if a Br. happens to be between two phenolic groups it is not substituted but really protected. We have obtained similar results, the NO_2 group substituting the CHO rather than the Br. atom, both of which are ortho- to the free phenolic group, in the di-brom derivative-β.

To substantiate the conclusions drawn we have also obtained independent evidence thus :—

(*a*) 2-4-6 tri-brom resorcinol-3-methyl ether was prepared and nitrated when D was obtained in good yields along with another product of lower M.P., still under investigation and this was further methylated to give E.

(*b*) 2-4-6 tribrom resorcinol was nitrated (Welelsky and Benedikt A. 164,7, Dahmer, loco-cit) and the 2-6 dibrom 4-nitro resorcinol (F) thus obtained, M.P. 148°C, was methylated when D was obtained as the main product. Thus of the two phenolic groups existing in F that which is para- to the most negative group, NO_2 was methylated in preference (a fact which we have often noticed in our work), and it was only by prolonged treatment with methyl iodide that the dimethyl ether, E, M,P. 81-82°C was also obtained.

53. The condensation of ketones with resorcinol. Part I.—*By* R. N. SEN *and* QUADRAT-I-KHUDA.

Acetone reacts with resorcinol in the presence of dilute hydrochloric acid when heated for several hours at 100°C. Mesityloxide is formed as an intermediate product and a molecule of this undergoes condensation with resorcinol. The product is deeply coloured in alkaline solution due to the formation of the quinenoid form: it yields a mono-benzoyl and a diacetyl derivative and combines with bromine to form a di and a tribromo compound. The following other ketones have also been successfully condensed and their derivatives studied :—Methyl ethyl ketone, acetophenone, cyclo-hexanone, isatin, benzal acetophenone and benzoyl acetone. For the condensation to take place a structure similar to that of mesityloxide seems to be necessary. Benzophenone remains unaffected due to the pronounced acidity of the two phenyl groups; however tetramethyldiamino benzophenone yields dihydroxy malachite green which is a deep blue solid exhibiting a pink colour in acid solution.

54. "Studies in Heterocyclic compounds."—*By* ANUKUL CHANDRA SIRCAR *and* PRAN KUMAR DE.

A number of compounds containing two dissimilar heterocyclic rings in their molecules have been prepared by the condensation of 2·3-diaminophenazine with various bodies, and the influence of the different heterocyclic rings on the properties of one another has been investigated.

55. The reaction between Hydrazine Hydrate and ortho-diketones.—*By* A. C. SIRKAR *and* H. K. PAL.

The reaction between Hydrazine Hydrate and ortho-diketones has been studied, and it has been found that not a trace of phenanthrone is obtained, as claimed by Dutt and Sen (J.C.S. *1923* I, p. 3420), by the action of Hydrazine Hydrate on Phenanthraquinone,—the only product formed being 9:10-dioxyphenanthrene (cf. Schmidt B. *35*, 3124). Hydrazine Hydrate reacts with camphor quinone in the same way as it does with isatin or benzil (cf. Curtius, B. *22* 2161–64; etc). In the reaction between Hydrazine Hydrate and acenaphthene quinone four different products are obtained; viz. those formed by the condensation of (*a*) one molecule of hydrazine hydrate with one molecule of the quinone; (*b*) one molecule of hydrazine hydrate with two molecules of the quinone; (*c*) two molecules of hydrazine hydrate with one molecule of the quinone, and (*d*) two molecules of hydrazine hydrate with two molecules of the quinone.

56. Production of formaldehyde by the dehydrogenation of methyl alcohol: A study of various catalysts.—*By* J. C. GHOSH *and* B. S. SREEKANTAM.

It is well known that copper obtained by reduction of precipitated copper oxide is a very efficient catalyst for the manufacture of formaldehyde from methyl alcohol. Unfortunately copper appears rapidly to lose its activity and only when hydrogen obtained according to the reaction $CH_3OH \rightarrow HCHO + H_2$ is removed by combustion with air, the activity of copper is maintained steady. The authors have studied the action of various copper catalysts prepared by different methods and have succeeded in obtaining catalytic copper which maintains a high and steady dehydrogenating capacity. The results, with some of the efficient catalysts, are given in Table I.

TABLE I.

Catalyst.	Best yield of formaldehyde in grams per hour per c.c. of Catalyst space at 175°c.	REMARKS.
1. Copper Sulphate and Ammonium vanadate (100: 1) precipitated with caustic soda and reduced at 180°C.	·3166 grams.	Worked for 60 hours, activity remained steady; with ageing, the secondary decomposition of HCHO into CO and H_2 or CO_2 and, CH_4 continually diminishes.
2. Pure copper acetate Solution precipitated with caustic soda and reduced at 180.°C	·3148 grams	This Catalyst has no promoter associated with it; worked for 16 hours during which the activity remained surprisingly steady. Beneficient influence of ageing observed.
3. Catalyst No. 2 with ·05% Nickel as promoter.	·5026.	,,
4. Catalyst No. 2 with 1% Nickel as promoter.	·3827.	,,

57. Action of Nickel on the system. C. H : C. H. COO.—*By* M. N. GOSWAMI.

The action of reduced nickel on unsaturated compounds is known to produce profound decompositions. It is now shown that the violence of the reaction is moderated by the proximity of carboxyl to the double bond. Cinnamic acid yields benzene, styrene, stilbene and phenyl acetylene along with gaseous products containing carbon dioxide, acetylene, and hydrogen. Esterification of the carboxyl makes the compound very stable, cinnamic ester being unaffected by nickel. However aceto-acetic ester which is an unsaturated compound in the enolic form undergoes the normal decomposition of acids yielding acetone, carbon-dioxide and ethylene; this is perhaps due to the activity of the molecule as a whole.

58. Iodination of Aromatic Hydro-Carbons.—*By* P. S. VARMA *and* D. A. KULKARNI.

Iodination of benzene and toluene has been carried out in the presence of a mixture of fuming nitric and nitrosulphonic acids. The reaction is completed within a shorter time and better yields are obtained than when nitric acid alone is used. The presence of a small quantity of glacial acetic acid markedly increases the yield; this perhaps is due to its solvent action on iodine. It is suggested that nitric acid actually takes part in the reaction producing an active nitro compound which readily takes up iodine eliminating the nitro group.

59. The sodium and potassium phenates.—*By* A. N. MELDRUM *and* M. M. PATEL.

The sodium and potassum phenates have hitherto been prepared by methods that are tedious e.g. by evaporating a solution of the phenate in a current of hydrogen or that lead to impure material, e.g., by evaporating a solution in water of the phenol and the hydroxide.

The authors find that in many cases a crystalline phenate is obtainable by dissolving the phenol in a dilute solution of the hydroxide and then adding a concentrated solution of the same hydroxide. In many cases the yield is good and the product is crystalline and has a definite melting-point.

60. A note on the preparation of acetonitrite.—*By* A. B. LIMAYE *and* D. B. LIMAYE.

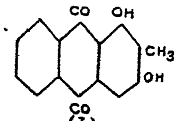
A modified method using cheaper material available in India is described, with good yield.

61. On Rubiadin.—*By* PRAFULLA CHANDRA MITTER *and* MONMOHON SEN.

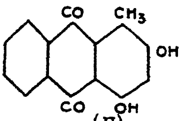
The constitution of Rubiadin was determined indirectly by Schunck and Marchlewski T. *63*, 969, 1137 (1893) *65*, 182, (1894) from the following data:—

(*a*) Its properties resemble very closely those of purpuroxanthin.
(*b*) The analysis agrees with that of a methyl purpuroxanthin.
(*c*) It does not possess a methoxyl group.
(*d*) On oxidation it gives phthalic acid which shows that both methyl and the hydroxyl groups must be in the same benzene nucleus.

(e) Of the two possible alternative formulae for rubiadin namely :—



(I)



(II)

(1) was synthesised by the above authors but the properties of the substance did not agree with that of rubiadin; and therefore formula (II) was ascribed to it.

We have succeeded in synthesising rubiadin by condensing 6-methyl-3-5-dioxy benzoic acid [prepared by a slight modification of the method of Jacobson (Ber, 16,1960)] with benzoic acid in presence of sulphuric acid.

A yellow crystalline product is obtained which dissolves in sulphuric acid with a yellow colour and in alkalies with a red colour. It melts at about 290°C.

Further experiments are in progress.

62. Karanjin Part II. Products of alkaline hydrolysis of Karanjin.—*By* D. B. Limaye.

Karanjin, when suitably hydrolysed with caustic alkali gives (1) benzoic acid (2) A phenolic body C_{11} H_{10} O_4 M. P. 93°C. (3) Karanjol-carboxylic acid $C_9H_6O_4$ which melts at 200°C with decomposition and gives a deep blue colour with ferric chloride and (4) a neutral, sweet smelling liquid with Ketonic properties, B.P. about 230°C.

These results lend additional support to the view that Karanjin may be related to flavone or flavonol group of substances.

63. Vidangin.—A colourless, crystalline constituent of Vidanga berries (*Embelia Ribes*).—*By* D. B. Limaye *and* A. B. Limaye.

A colourless constituent M. P. 115°—116°C. hitherto not isolated from the berries, has been described; on oxidation, it gives orange flakes M. P. 142°C.

64. Note on a Preliminary Chemical Examination of Bitter Gourd (*Momordica Charantia*).—*By* B. Viswa Nath.

A preliminary chemical examination of Bitter gourd (Momordica Charantia) has shown that the fruit has a high nutritive value and that the active and bitter principle is a resin of glucosidic nature.

65. " A Preliminary Note on Morellin an orange crystalline substance present in the husks of *Garcinia Morella* ".—*By* Madyar Gopal Rao.

Morellin a crystalline colouring matter present in the husks of G. Morella and the various derivatives of Morellin are described in this paper. The author, from the data collected by him, is of opinion that Morellin is C_{15} H_{16} O_3 and that, unlike Mangostin (cf. Dekker Rec. Tran. Chim. 1924. 43. 727) from G. Mangostina it is not a Lapachol derivative, but that it would appear to be in all probability a derivative of Hydroxy Y Pyrone with an Iso-Amyl side chain.

66. The Essential oil from the flowerheads of *Perovskia atriplicifolia* Benth.—*By* MADYAR GOPAL RAO.

The essential oil from the flowerheads of *Perovskia atriplicifolia* Benth is described and is shown to contain about 50%Terpenes among which d α Pinene, β Pinene and Camphene have been definitely identified, 15% of alcohols and esters, chiefly *d* Borneol and Bornyl acetate, and the rest of sesquiterpenes consisting chiefly of α Caryophyllene and Aromadendrene.

67. The Essential oil from Andropogon Martini.—*By* KHWAJA HABIB HASAN.

The physical constants resemble closely with those of other essential oils. The specific gravity varies from O. 875—0·878 and is almost optically inactive rotating from −2° to +2°. The oil completely dissolves in 70—75% alcohol.

The various fractions of oil yield varying proportions of geraniol, acetic and caproic esters, methylheptenone and the terpenes. The amount of esters is 10—20% and free alcohol about 70—80%.

68. The Constituents of the Essential Oil from the Roots of Kampferia galanga.—*By* P. B. PANNICKER.

The author has investigated the constituents of the oil obtained by the distillation in steam of the roots of *Kampferia galanga*. The following substances were isolated:—1—Δ^3—carene, camphene, borneol, *p*-methoxystyrene pentadecane, ethyl cinnamate and ethyl *p*-methoxyycinnamate.

69. Attock Petrol.—*By* RATTAN CHAND HOON.

Attock petrol contains no hydrocarbons which are not liquid at ordinary temperatures. It distils quantitatively from 35° to 174° C.

The petrol was first fractionated in Thole's apparatus (J.S.C.I., 1919. *38*. 39. T). Up to 60°C the fractions are small. The bulk of the petrol distils between 95° and 110° C.

The results of nitration, oxidation and sulphonation indicate the presence of very small quantities of aromatic hydrocarbons.

The separation of the constituents has been carried out by Sydney Young's method, *i.e.*, by eliminating aromatic hydrocarbons before fractionation. Only the fraction of the petrol distilling up to 105°C has been studied. Pentane, pentamethylene, hexane, hexamethylene and heptanes have been isolated.

The nitration of the fraction with one part of nitric acid and two parts of sulphuric acid to eliminate aromatic hydrocarbons gives two compounds (*a*) $(C_4H_4O_3)_x$. B.P. determination indicates $x=2$. M.P. 71—72°C. and (*b*) M.P., 174°C contains nitrogen. It is insoluble in most organic solvents. These compounds are being further investigated.

70 Chemical constituents of the lower boiling fractions of Indian Turpentine.—*By* H. M. MULANY *and* E. R. WATSON.

It is doubtful whether even the fraction of Indian turpentine which boils at 155-160°C at ordinary pressure contains any appreciable quantity of pinene. It will not give any solid pinene hydrochloride, it gives an oxidation product (pinonic acid ?) which will not crystallise even when it has been fractionated under reduced pressure, it gives only a trace of pinene picrate, a very small yield of pinene nitrosyl chloride and a very small quantity of sobrerol by Henderson's method and it does not give dipentene on heating in a closed vessel, whereas the fraction boiling at 155-160°C. obtained from foreign turpentine gives all the above reactions for pinene in a satisfactory manner. It contains some Δ^3-carene as it gives the nitrosate but the yield of the latter is not large. The oxidation product (pinonic acid ?) gives an oxime melting at 121-2°C, whereas foreign turpentine gives the oxime of 1-pinonic acid. m.p. 131°C.

71. Manufacture of strychnine and Brucine from nux vomica.—*By* H. D. SEN *and* E. R. WATSON.

On a semi-large scale the extraction of nux vomica by dilute alcohol, distilling off the alcohol, removing tannin by lead acetate and precipitating the alkaloids by alkali gave a poor yield of impure alkaloids. Treatment of the nux vomica with lime and caustic soda solution and extraction of the alkaloids by agitating the aqueous mixture with kerosene was unsatisfactory on a semi-large scale owing to the formation of emulsions. Satisfactory extraction has been obtained by (1) Softening the nuts by heating with steam under pressure (2) mixing with lime and drying (3) extracting the alkaloids from the dried material by kerosene at 100°C.

72. The Recovery of Sugar from cane sugar molasses.—*By* K. C. MUKERJEE, E. R. WATSON and others.

Cane sugar can be recovered from cane sugar molasses by a modification of Batelle's process, viz., boiling the molasses with lime to destroy invert sugar, precipitating the sucrose by further addition of lime under suitable conditions, filtering off the tricalcium sucrate and decomposing by carbonation. In a first series of experiments 71 per cent of the sucrose was recovered but was mixed with other substances (not invert sugar or inorganic salts) so that it had a purity of only 64. The tricalcium sucrate seems to carry down some soluble substances by adsorption. Some of these impurities could be removed by a preliminary carbonation before the tricalcium sucrate was precipitated and then 50 per cent of the sucrose was recovered with a purity of 74.

In a second series of experiments it has been found possible to get a more complete precipitation of the sucrose as tricalcium sucrate and without any preliminary carbonation 84 per cent of the sucrose has been recovered with a purity of 71. The work is being continued.

73. Production of alcohol from kanki or broken rice and other starchy materials by the amylo-process.—*By* K. R. GUPTA *and* E. R. WATSON.

By the use of a mould and yeast recommended by Jörgensen (*Mucor Rousianus* and his yeast No. 1133) only 50 per cent of the theoretical yield of alcohol was obtained. By the use of one of the moulds which grow spontaneuosly in Cawnpore a yield of alcohol equal to 78 per cent of theory was obtained. Hutchinson and Ayyar by the use of Indian Rice Beer Ferments in open vessels were able to get yields of about 65 per cent of theory.

Boulard moulds and yeasts, which are stated to give 97.5 per cent of the theoretical yield of alcohol, are only supplied to distillers signing a contract to pay to the Societe' d' Exploitation des Procedes H. Boulard a royalty on all alcohol produced by the process.

74. The heat balance of an oil-fired glass furnace.—*By* HEMENDRA KUMAR SEN *and* MANINDRA KUMAR SEN.

The paper embodies the results obtained from an oil-fired experimental glass furnace, having a capacity of 200 kgs per nine hours. Calculation of the heat balance shows that the efficiency of an oil-fired system is decidedly greater than that of a coal-fired or gas-fired one, and it has been found that by preheating $\frac{2}{3}$ of the total air up to 1000°C and preventing secondary losses, this efficiency may be further increased.

The main losses of heat were due to conduction through the walls of the furnace and to the loss of thermal energy in the products of combustion leaving the furnace The former amounted to 214074 Calories or $\frac{214074 \times 100}{607,200} = 35.25\ \%$ of the total Calorific value of the fuel.

The latter equalled on an average 375,000 Cals, of which under exceptional cases 156,525 calories were being returned to the furnace through the Secondary air preheated by an efficient recuperator, but under average working conditions 130,435 Cals or sometimes even less.

The advantages in oil-firing over coal-firing are less expense, fewer workingmen, less attention, cleanliness, perfect control of the nature of the flame so essential in making colourless glass in *tank furnaces*, and less block expenditure.

The maximum temperature attainable in an oil-fired furnace under working conditions is somewhere between 1600 and 1700°C, depending on the quantity of excess air, its preheating and conduction of heat through the walls. The last point is of considerable importance, the ratio $\frac{A}{r}$, i.e. the relation between the surface of the walls to the thickness requiring to be kept as low as is consistent with the cost of erection. As the temperatures of the innerface and outerface of the walls represent after a time the equilibrium temperatures, it is obvious that the heat conducted through the walls per unit of time must also be that lost by radiation of the outerface in the same period. It is possible, therefore, to check the value of the modulus of conductivity of the brick wall, by knowing the value of radiation per unit of surface at different temperatures. Calculating with the help of Langmuir's data, the temperature of the outerface of the furnace in question should be 270°C, whereas the actually observed average was 252°C, which may be considered good agreement in consideration of the various uncertainties in such measurements.

The theoretical temperature of an oil flame with 10% excess air, and 66% of the required air, supplied at 1000°C, is approximately 2400° absolute, as calculated from thermodynamical considerations. The loss by conduction through walls being 214074 Cals, and the heat brought into the furnace being 763,725 Cals, the calculated temperature in the furnace should be 1523°C. The average of the observed temperature in the reference furnace was 1500°C.

75. Ultramarine Blue from Indian raw materials.—*By* GAURI KANTA MUKHERJEE.

The replacement of natural kiesselguhr by the artificially prepared one although not altogether successful, has given Shades of blues which on careful elutriation yield a product only very slightly inferior to the imported pigment of good quality. Rajputana kaolin was found quite suitable for the production of the best ultra marine with Kiesselguhr. The common test for good clays is to ignite them; those that give a brown tinge on ignition must be discarded, as they yield a dull coloured finished product. The following mixture was found to give excellent results :

Kaolin (dried)	80 parts :
Silica (dried) or .. .. .. Kiesselguhr	11 „
Soda (anhydrous)	88 „
Sulphur	73 „
Carbon (soft wood charcoal)	10 „

Greatest care must be taken to obtain as uniform and fine a mixture as possible. The quality of the pigment depends considerably on this. The bluish-green pigment obtained by calcining the mixture between 750–800°C in clay crucibles arranged in layers, is mixed with 8% of its weight of sulphur and roasted in a muffle furnace till all the sulphur is burnt off when the furnace is closed and allowed to cool slowly. The blue mass is then ground, lixiviated, collected in grudes, dried and re-ground.

The analysis of an average sample of the best quality is given below:

Insoluble residue (silica, etc)	42·7%
Sulphur (not free)	12·6 „
Al_2O_3	25·1 „
Na_2O	19·4 „
	99·8 „

76. Note on the Classification, Concentration and Briquetting of Chrome and Manganese Ores.—*By* K. R. KRISHNASWAMY.

Chrome ores differ considerably in appearance on fracture, and it has been found that in any one locality it is possible to classify ores into types with a definite percentage of chromium merely by their appearance. The types vary in different localities. Manganese ores cannot be classified so readily. Specific gravity affords no clue to the grade of an ore.

Many low grade chrome ores may be concentrated by powdering and passing over a Wilfley table. The losses of chromium in the tailings are small. With manganese ores the losses are much greater.

Sodium silicate solution is one of the best binding materials for briquetting these ores when powdered.

77. Influence of temperature on metabolism and the problem of Acclimatization.—*By* N. R. DHAR.

1. (*a*) Rubner from his experiments concluded that the metabolisms in different warm blooded animals were constant when expressed per square meter of the body surface.

(*b*) Experimental results show that smaller animals have greater metabolism in a unit time per kilogram than larger animals.

(*c*) The metabolism of warm-blooded animals increases when there is a fall in temperature of the surroundings. These biological facts have been explained from Stefan's law of radiation.

2. The physical activity and the amount of oxidation per unit weight of the body are greater in the smaller animals than in larger ones. In the process of metabolism extreme active catalysts are likely to lose their catalytic activity more readily than moderately active catalysts; and that is why death is more rapid with smaller animals than with larger ones.

3. The effect of transporting a warm-blooded animal from a warmer country to a colder country is to increase the activity of the body enzymes and to increase the metabolism and to shorten the life of the animal in question. If a warm blooded animal is transported from a cooler country to a warmer country the metabolism and the catalytic activity of the enzymes are decreased. Hence longevity of the animal in question is likely to be increased.

When a warm blooded animal has to live in a country where the out side temperature is usually greater than the body temperature, the animal is likely to age and grow old and die more readily than an animal living in a cold country.

4. When a cold blooded animal is transported from a warmer to a cooler country the metabolism of the system is decreased and the body

enzymes will not age as rapidly as they would do in a warmer country; consequently both these factors lead to a greater longivity of the cold blooded animal by transportation. When a cold blooded animal is taken from a cooler to a warmer country the metabolism will be increased and the enzymes will age more rapidly; hence the effect of both these factors will be that old age and death will follow more readily though the animal will live a more intense life in a warmer country.

78. Micro-determination of Enzymic Activity.—*By* B. N. SASTRY AND M. SREENIVASAYA.

As one result of enzyme action the substrate undergoes change in its molecular state, and therefore in some of the physical properties of the solution. Attempts have been made from time to time to follow the activity by determining changes in viscosity, electrical conductivity, optical activity, refractive index and the freezing point. The present method takes advantage of the change of vapour pressure due to the change in the number of molecules, as a result of enzyme hydrolysis, and is an application of Barger's well known microscopic technique for determining molecular weights.

A series of drops consisting of the active solution is alternated with a series of inactivated controls in a thin capillary tube which is sealed. Measurements of the change in the size of the drops are taken at definite intervals with the aid of a micrometer. Experimental drops increase in length at the expense of the controls, such increase representing the measurable activity of the enzyme. Precautions necessary for the attainment of accuracy by the micro-method are given in full detail.

79. The fermentation of Toddy and the micro-organisms responsible for it.—*By* M. DAMODARAN.

A study of the micro-organism responsible for the fermentation of toddy from cocoanut and other palms is interesting not only theoretically but also from the practical aspect in view of the possible control of the process. In the present paper an account is given of :—

I. An analytical study of the different end products of fermentation and especially of the organic acids produced.

II. The different varieties of yeasts present in fermenting toddy, their morphological and biochemical characteristics and the particular fermentation products for which each of them is responsible.

III. The bacteria which, under ordinary conditions of tapping are always found accompanying fermenting toddy.

80. The phenomenon of 'Bulking' and its relation to the chemical and biological factors in activated sludge.—*By* N. SWAMINADHAN.

In a paper read at a previous session of this Congress it was shown that the immediate cause of 'bulking' in activated sludge tanks is the presence of filamentous growths and other higher forms of life. It was also suggested that the phenomenon is associated with insufficient aeration.

During the course of this year "bulking" has again been occasionally observed and a detailed study undertaken in order to ascertain its relation, if any, to the chemical and biological factors in the sludge. The association of 'bulking' with the filamentous growths previously described has been confirmed and the organism isolated. Though these filaments do not greatly retard precipitation of organic matter in the sewage, there is found in the effluent and floating in the settling chamber much suspended matter partly due to the breaking up of the filaments.

The latter also appear to serve as a substrate for higher organisms and rotifers are very numerous during the 'bulking' period. With ample aeration, though the sludge settles quite well, its gelatinous character does not disappear. The water content of the sludge is 98%. The filaments are straight, unbranched organisms which grow on nutrient agar. Young cultures (18 hours) are filamentous but break up after 24 hours. The organism does not thrive in acid media, is gram positive and does not produce acid or gas. Its appearance is not restricted to any definite period of the year.

81. Experiments on the dewatering of activated sludge.—*By* N. SWAMINATHAN.

Activated sludge retains most tenaciously the water present in it. The water content of the sludge produced in the plant at the Indian Institute of Science, Bangalore, ranges from 97 to 98% when in good condition. Whenever 'bulking' appears the water content may be as high as 99%.

Experiments on the dewatering of the sludge have been conducted in these laboratories on the lines of Wilson and Heisig's work (*J. Ind. and Eng. Chem.* 1921, *13*, 406). Varying amounts of acid in increasing quantities have been added to definite portions of the sludge and filtration of the sludge on the laboratory scale has been effected. The use of varying quantities of a normal solution of aluminium sulphate has also been tried.

It has been found that the addition of acid brings about flocculation easily, the colour of the sludge changing from black to brown. Filtration is rapid when the P_H of the sludge lies between 3 and 4. Addition of aluminium sulphate does not produce visible flocculation but results in very satisfactory filtration and the formation of a very porous sludge cake.

Drying of the sludge on sand beds and turf has also been tried. If the layer of sludge is half an inch thick or less, it dries into workable cakes in less than 18 hours; thicker layers require 48 hours or more.

82. Effect of neutrals salts on the basicity chrome liquors.—*By* B. B. DHAVALE.

In continuation of the work on the changes in basicity that the addition of different quantities of sodium chloride brings about in chrome liquor a study is made of the effect produced by potassium chloride, potassium sulphate and sodium sulphate. Potassium chloride resembles sodium chloride in causing a steady rise in basicity until it reaches a maximum whereafter it keeps constant. With potassium-sulphate as with sulphates in general there is a decrease in acidity followed by an increase at higher dilution. In the case of sodium sulphate there is a gradual increase in basicity until it goes to a maximum followed by a gradual decrease almost to the original figure.

83. Practical investigation of some Indian tanstuffs.—*By* B. M. DAS *and* U. N. DUTT.

With a view to discover new vegetable tanstuffs thirty-three varieties consisting of barks, leaves, fruits etc. were collected and their tannin contents determined. Hides and skins were tanned with these materials and the properties of leather produced were noted. Out of the thirty-three, twenty were found quite suitable for direct use in tanning. Thirty varieties in which the ratio of tans to non-tans was found to be greater than one were considered suitable for making tannin extracts.

84. Investigation on the effect of renewal of lime liquors on hide substance dissolved and gain in pelt weight.—*By* B. M. DAS, B. B. DHAVALE *and* B. N. PAL.

It is generally held by practical tanners that more hide substance is dissolved by the lime liquor if liming be done for a certain period in one liquor only than if it were carried out for the same period in three or four fresh lime liquors. The present investigation has yielded results contrary to popular belief and corroborate those obtained by McLaughlin and Theis in America.

85. Fermentation of Divi Divi Liquor. Acidity of Divi Divi liquor.—*By* K. SESHACHALAM CHOUDARY *and* E. YOGANANDAM.

One of the most important changes taking place in a tan liquor during fermentation is the increase in its acidity. The acidity of the tan liquor is measured by the Procter's Lime Water Method and the hydrion concentration by the Comparator Method, as adopted to tan liquors by Atkin and Thompson. During fermentation of a divi divi liquor the acidity goes on increasing to a maximum and then falls down to an almost constant value, whereas the hydrion concentration remains almost constant from the very beginning. The variation of the acidity (both volatile and non-volatile) of the liquor and the hydrion concentration of a divi divi liquor undergoing fermentation, with the temperature of extraction, presence of the tanning material in the liquor, addition of acid and glucose, have been determined.

86. Comparative study of South Indian Tanning Materials.—*By* K. SESHACHALAM CHOUDARY *and* E. YOGANANDAM.

Eight South Indian Tanning Materials were analysed. It is not the amount of tannin absorbed by chromed hide powder alone that determines the value of a tanning material. It has been amply shown by modern research that there are other and more important factors which have to be taken into account of, the most important of these being the quantity and the nature of the non-tannins present. The ratio of the non-tannins to the tannins, the acidity of the liquors, the destructive losses taking place during the fermentation of the liquors, the percentage of sugar, and the speed of diffusion have been determined with each tanning material. Divi Divi, Myrabolams and wattle are the richest in tanning content. Divi Divi and myrabolams contain greater quantities of sugar and lose tannin most during fermentation.

87. The electrolytic production of Dicalcic Phosphate from Apatite in India.—*By* S. DAS.

1. Phosphatic nodules and apatites available in India are not suitable for the manufacture of superphosphate owing to the presence of deleterious chemical substances leading to a waste of sulphuric acid, which is neither cheap nor plentiful in India.

2. Phosphatic nodules are not suitable for the preparation of dicalcic phosphate by the electrolytic method due to high calcium carbonate content amounting to nearly 20 per cent.

3. Apatite can be utilised successfully and economically for the manufacture of dicalcic phosphate by the electrolytic process, provided cheap hydro-electric power is available in India.

4. Dicalcic phosphate is superior to superphosphate as a phosphatic fertilizer in many respects, *e.g.*—

(*a*) It can be used for all types of soils, whereas the application of super is restricted to particular soils only.

(*b*) Railway freight of dicalcic phosphate is only half of that of super for a given amount of phosphoric acid.
(*c*) Dicalcic phosphate does not suffer retrogradation when stored, like super.
(*d*) Sacks are not damaged by this product, as in the case of super.
(*e*) It will be very useful in the making of "Complete Fertilizers".

88. Effects of Chalk on a non-calcareous soil.—*By* S. Das.

1. That the addition of chalk to a non-calcareous soil increases the crop yield has been corroborated by pot-culture experiments.

2 The increased yield is attributed, among other factors, to the supply of calcium to the soil naturally deficient in that constituent, the change of reaction of the soil in that its pH rises from the initial value of 6. 3 to 7. 0 or more, and also to the improvement of physical texture of the soil by its mechanical opening.

3. The latter has been shown to be the case, when part of the chalk added to the soil is replaced by an inert substance like sand.

4. That the mechanical opening of the soil takes place on the addition of chalk has been definitely proved by—

(*i*) decreased water-holding capacity attained on the addition of chalk alone or of sand with a fixed amount of chalk;
(*ii*) increased percolation when increasing proportions of sand are added to the soil; and
(*iii*) increased yield of crops on the addition of sand as shown by pot-cultures.

89. Synthesis of Condensed Heterocyclic Systems—Interaction between 2 : 5-Dithiol-1 : 3 : 4-Thiodiazole and some Organic Dihalides.—*By* Prafulla Chandra Rây *and* Bires Chandra Guha.

The work of Rây, Guha and Das (*J. Chem. Soc.*, 1919, *115*, 1308) on the condensation of some heterocyclic mercaptans with reactive halogenated organic bodies has been extended. The reactions between 2 : 5-dithiol-1 : 3 : 4-thiodiazole on the one hand and ethylene bromide, benzal chloride, and thiophosgene on the other have yielded interesting fused-ring heterocyclic compounds and also some new heterocyclic mercaptans in each case. In the condensation between the dithiol and ethylene bromide a peculiar chain compound of sulphur was obtained containing as many as seven thiodiazole groups all linked up through C_2H_4 residues. The dithiol failed to condense with ethylidene chloride and as shown previously (*loc. cit.*) it did not also react with chloroform, bromoform, etc. This shows that the halogen atoms attached to the same carbon are probably less reactive than those attached to different carbon atoms. The presence of negative groups, of course, renders the halogen atoms labile even when they are attached to the same carbon atom. The suggestion (*loc. cit.*) that the presence of two SK groups probably inhibits reaction has now been supported by the observation that the sodium salt of dithioethylene glycol also does not react with chloroform while sodium ethyl mercaptide does (Gabriel, *Ber.*, 1877, *10*, 1805; Holmberg, *Ber.*, 1907, *40*, 1740).

90. The mechanism of Formation of 2 : 5-Dithiol-1 : 3 : 4-Thiodiazole from Carbon Disulphide and Hydrazine. —*By* Prafulla Kumar Bose *and* Bires Chandra Guha.

In this paper the uncertainty regarding the mechanism of formation of the dithiol has been sought to be removed. The intermediate compound which was regarded by Busch (*Ber.*, 1894, *27*, 2518) as the hydrazine salt of the dithiol and by Losanitsch (*J. Chem. Soc.*, 1922, *121*, 2542) as dithiocarbazinic thioanhydride has yielded, on condensation with benzaldehyde, a dibenzylidene compound namely di-5-phenyl-4 : 5-dihydro-1 : 3 : 4-thiodiazolyl sulphide which points in favour of Losanitsch's view. Losanitsch's idea that in the formation of dithiocarbazinic thioanhydride from ammonium dithiocarbazinate, thiosemicarbazide steps in as an intermediate compound appears, however, groundless for an attempt to condense ammonium dithiocarbazinate with thiosemicarbazide directly under the experimental conditions described by Losanitsch has failed. The reaction of the dithiocarbazinic thioanhydride with carbon disulphide has yielded a compound not yet identified which gives a very sensitive colour reaction with alkalis.

91. The Constitution of Complex Platinum Compound derived from Platinic Chloride and Ethylsulphide.—*By* PRAFULLA CHANDRA RAY *and* BIRES CHANDRA GUHA.

Some of the complex platinum ethylsulphide compounds (Ray and Bose Ray, J. Indian Chem. Soc., 1925, 2,) on treatment with ammonia and pyridine have yielded compounds of the true Werner type in which each Et_2S residue has been replaced by $2NH_3$ and one Py respectively. This evidence is obviously in favour of the Werner constitution of these complex compounds. Further work is in progress.

92. Physical Chemistry of Metal Ammonium Compounds. Part I. The Blue of the Copper-Ammonium Compounds.—*By* S. S. BHATNAGAR, MATA PRASAD, *and* DINA NATH.

It has long been known that blue colour of an ammoniacal solution of copper salt is due to the complex copper-ammonium ions. In the present investigation the authors have found that a similar blue coloured solution of copper salt can be prepared by adding a weak solution of sodium hydroxide to it in presence of gelatine or any peptizing agent. By comparing the absorption spectra of the ammoniacal solution of the copper salt and the colloidal solution prepared as above or by the electrolysis of KCl solution, with copper as the cathode, it has been shown that the blue of the ammoniacal solution is due to the copper hydroxide which has been peptized by ammonia. The colloidal nature of the copper ammonium solution has been further shown by some experiments on dialysis, cataphoresis and the coagulation by electrolytes.

93. Theory of the Wehnelt Electrolytic Interrupter.—*By* S. S. BHATNAGAR *and* KAILASH NATH MATHUR.

The mechanism underlying the working of the Wehnelt Electrolytic Interrupter has been the subject of the present investigation. It has been found that the efficient working of the interrupter depends upon—

(*a*) the size of the aperture at the bottom of the porcelain tube,
(*b*) the length of the platinum wire protruding out of this aperture,
(*c*) the diameter of the platinum wire,
(*d*) the applied potential,
(*e*) the strength and temperature of the acid solution,
(*f*) the self inductance of the circuit.

With a proper adjustment of the first three conditions, it has been found possible to work the interrupter with voltages down to 6 volts, which ordinarily works between 60–80 volts.

The 'make and break' have been shown to depend upon the constant formation and collapse of the bubbles of the electrolytic gas liberated at the anode.

94. Determination of Potash by perchloric acid method.—*By* N. C. Basu.

1. Estimation of potash by platinic chloride method is too expensive and has no particular advantage over perchloric acid method. Moreover the results obtained are not always concordant on account of the uncertainty of the strength of alcohol to be used for washing. It would seem advisable to abandon this method.

2. The most convenient strength of alcohol to be used in washing potassium perchlorate is 97 to 98% containing ·2% perchloric acid, of which about 60 cc. is necessary for each estimation.

3. The perchloric acid used for potash estimation should not give any appreciable residue on evaporation and should give an exact result with pure potassium chloride.

4. Barium and calcium salts do not interfere with the result; Sodium salts if present in large quantities tend to increase the result.

Section of Zoology.

President:—H. R. MEHRA, PH.D. (Cantab).

Presidential Address.

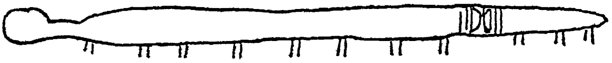
CERTAIN PROBLEMS OF REPRODUCTION.

I deeply appreciate the honour conferred upon me to preside over the section this year.

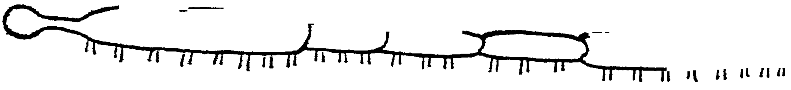
I am taking up a theme for the address in which not only am I interested, but which also involves a number of problems of a general nature, which need the attention of workers in other branches. To tackle them properly it is necessary to follow the advice given by the late Dr. Annandale to the members of this section a few years ago in the following words:—

" Zoology has become so complicated that few of us now-a-days are more than "Scarabees." This is an immoral state. not only because no man has the right to narrow his interests to a single family of beetles, but also the whole of Biology is at present encumbered with uncoordinated details that clog the machinery of progress instead of acting as motive force." I shall consider the phenomenon of asexual reproduction in the Microdrili, its connection with sexual reproduction and other kindred subjects, which have a bearing on the origin of germ cells, the development of organs and facts of experimental embryology.

While we know that reproduction is effected as usual in the metazoa by germ cells only in all the terrestrial Oligochaetes, which form the order Megadrili, in two out of five families of the order Microdrili commonly known as aquatic Oligochaetes, the usual and predominant mode of reproduction is by fission and budding. These two families, i.e. Aeolosomitidae and Naididae comprise small delicate worms, which are found all over the world in fresh water ponds, pools, rivers and other places where the water usually remains stagnant for some time. In the Aeolosomitidae sexual reproduction is practically unknown and sexual organs very rarely seen. The only account of sexual organs is from D' Udekem, Maggi and Stolc. The work published by the last author in 1889 is the latest on the subject. D' Udekem had observed that sexual and asexual reproduction may be carried on pari passu. Beddard kept under continual observation a quantity of *Aeolosoma tenebrum* for more than a year without once seeing the clitellum or sexual organs. The sexual organs have never been so far observed in any Indian species of this family. Stephenson in his Indian Fauna volume writes "The sexual organs have been rarely seen in this genus; if they are seen to be present in any Indian Aeolosoma, the worms should be carefully fixed and sectioned and condition fully described." I have been constantly keeping a fairly close watch for the last seven years on the two species of this genus found in Northern India, viz. *A. kashyapi* and *A. viride* at different times of the year, but I have never met with any worms having sexual organs. From this it would be clear that worms constantly reproduce asexually and in most of the species any how sexual reproduction has probably dropped off.



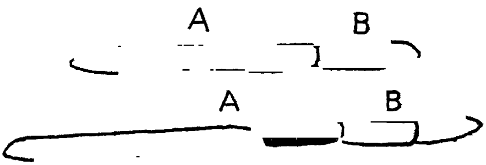
Aeolosome viride is rarely found without a budding zone, on the other hand it generally exists as a chain of 2–5 individuals, of which the anterior one is the parent bearing 8–11 setae bundles. The zone of budding arises after the 7th or 8th setae bundle i.e. after the 8th or 9th segment. Here a rapid production of new segments takes place and of these two or three anterior ones with 8 or 9 segments of individual in front are separated off by fission to produce the normal individual consisting of 11 or 12 segments, so the worms showing a larger number of segments than this indicate by the arrangement of the bundles and by commencing constrictions that they are preparing to divide. In the hinder part of the chain the division into individuals is much more irregular and there may be three zones of budding behind each group of three successive segments which lie in front of the last zooid.



This shows that the embryonic tissue capable of development into organs or parts of the body is contained after the first 7 segments in a more or less fully developed worm, but it lies before and after the first three segments in an animal, which though attached to the parent individual is incomplete in its development. I use the term embryonic tissue to indicate that it has the power of growth and development. I would compare it with meristic tissue in plants to illustrate this meaning, though this comparison should by no means be stretched too far. The first and last individuals of a chain are more complete and at a stage of much greater development than the middle ones which have been intercalated between them before they are separated by the formation of new tissues. In Aeolosoma the embryonic tissue is capable of forming complete new individuals and the budding zone varies its position in proportion to the age of development of the worm. If, following Bourne, we denote by *n* the number of segments of the parent individual, behind which the budding zone appears, we may say that the position of *n* varies in proportion to the development of the worm in which it appears, and that in the more or less fully developed specimen of this species it appears to be constant varying within narrow limits, i.e. lying after 7 or 8 segments.

We know that reproduction is a form of growth beyond the limits of the individual, by which successive generations are continuous with one another. In many animals specially metazoa, with some exceptions, this kind of permanent growth is possible only by the agency of a sexual process, i.e. sexual reproduction. But in Aeolosoma, in some species at any rate, it appears, that this sexual process has somehow got out of joint and dropped off, and that reproduction always takes place by fission preceded by the formation of new segments by budding or gemmation. Beddard found that this annelid can encyst itself. The cysts, spherical, oval or irregular in form, are of variable thickness and are found at the end of autumn or at the commencement of winter. The encystation is not a phenomenon, which we ordinarily associate with the metazoa, and its interpolation here in the life cycle is a measure of protection against approaching adverse conditions due to adaptation for pond life, which as we shall see, is provided in the case of the Naididae by sexual reproduction.

In the Naididae while the sexual organs have been observed in various genera found in India and Europe, it is held by all workers on the subject that they are developed not more than once in a year and that asexual multiplication by fission is the common mode of reproduction. The budding zone varies in position. Bourne thought that *n* would be constant for each species, but since then it has been found by Benham, Piguet Stephenson and myself that in a large number of species it varies within somewhat wide limits in different individuals. In Chaetogaster single individuals are rarely met with, and in most cases indications of approaching fission are evident; *n* is fixed for each species; in *Chaetogoster langi* it is 8 or 9, in *C. orientalis* 8, and *C. bengalensis* 10 or 11. Specimens of *C. langi* are divided by a well marked constriction into two parts, an anterior of at least 8 body segments and a posterior of varying length. These two principal parts are again divided by slighter con-



strictions. The posterior portion when it comprises 8 segments is divided into two parts, each containing four pairs of setae bundles; the anterior zooid also has the four posterior segments separated by a distinct constriction from the front part which consists of 11 segments. New segments are formed on both sides of the region of constriction. In *Chaetogoster orientalis* the single individual consists of about 11 segments, but it is rarely found. In the zone of budding, which occurs after the 8th segment there are intercalated 8 segments of which the three anterior ones belong to the first half and the five posterior become the anterior five segments of the second zooid. The setae of the 9th original segment now belong to the 6th segment of the second animal. Three more segments are produced at the end of the parent individual to complete the second zooid consisting of 11 segments. So we have in all 11 segments for each half. In chaetopods the number of segments generally continues to increase throughout the life of the animal due to the activity of a zone of proliferation at the hinder end just in front of the anus. In *C. orientalis* the last three segments of the posterior zooid, which are newly formed are the result of the activity of this region. The body of the 2nd zooid then contains only 3 segments belonging to the parent individual, while the five anterior are formed by the budding zone and the three posterior by the hinder proliferating region and we have seen that the former lies only three segments in front of the latter in a more or less complete worm. The worm does not divide at this stage, but the two zooids remain attached till at least a part of the above process has been repeated in each of them. Like Aelosoma it is usual for Chaetogoster to be composed of several zooids and when separation of a daughter individual takes place, it already indicates signs of budding. The number of segments being small Chaetogoster also resembles Aelosoma in having *n* fixed for each species. As in Aelosoma the budding zone lies near the hinder end of the body.

In Nais the position of *n* varies among individuals, but generally its position is somewhat about the middle of the body. It varies within narrow or wide limits in different species of Aulophorus. In *A tonkinensis* *n* is 17 or 18, in *A. Michaelseni* 22 and *A. furcatus* it varies from 18–25 and in *Haemonais laurentei* from 31–36. In *Nais pectinata* the budding zone has never been observed. The body breaks up into two parts; the anterior part produces a new hind end and the posterior part a new head. So it is a normal occurrence that the two parts develop into individuals like the parent. In other species of Nais there is a distinct budding zone in the body before it divides by fission. As for instance in *Nais raviensis* where the position of *n* is 13, the prostomium and first four segments of the hinder zooid are formed in the budding zone before separation. *Nais pectinata* shows a primitive condition of asexual reproduction where the body first divides into two parts, each of which reproduces the lost parts. The power of asexual reproduction is thus closely associated with the power of reproducing lost parts and with the power of growth after the adult condition has been attained. According to Stephenson various stages in the evolution of asexual reproduction by fission are shown by the different species of the genus Branchiodrilus. In *Branchiodrilus semperi* fission takes place without the production of a budding zone, but before division a prostomium and a new first segment are formed. The worm does not possess a long cephalished region composed of a prostomium and four segments. The next stage is shown by *Branchiodrilus menoni*, where a few more segments behind the first are produced after separation. The number of new segments in this species has not become fixed. The next stage as in *B. hortensis* is the formation of these segments in the budding zone before separation and the fixing of their number. In *Slavina appendiculata* though the number has become fixed, they are not all formed before separation; in other genera such as Nais except N. pectinata, Stylaria, Dero, Aulophorus and Pristina, however, the full number is formed in the budding zone, but the segments differ from the rest in being less completely developed.

Many Polychaetes also exhibit asexual reproduction, which bears a close resemblance to that described above in the Naididae. In the simplest case as in Filigrana and Salmacina, the sexual cells make their appearance in the hinder segments in front of which a zone of fission is formed. This zone becomes differentiated into an anal region for the part of the worm in front, and a cephalic region for the part behind, which becomes the sexual zooid. The subsequent fission results in the division of the worm into two, i.e. asexual and sexual individuals. The family Syllidae comprises small worms which are well known among Polychaetes for their remarkable power of asexual reproduction. When the entire animal is transformed into a reproductive individual very much like Heteronereis, the condition is called Epigamy. When a part of the worm containing reproductive organs is separated off and becomes a free swimming individual, the phenomenon is known Schizogamy, as in Syllis and Trypanosyllis. The worm divides into an anterior non-sexual portion and a posterior sexual portion. The family may be divided into two groups according to whether they exhibit Epigamy or Schizogamy. In Odontosyllis and Exogone the posterior segments in which the genital organs exist, become altered, so that the worm consists of two distinct portions and is called a "Heterosyllis." These changes are quite similar to those which characterise "Heteronereis," and the modified genital region of the body is not separated. In the epigamous group of which

Haplosyllis spongicola may be taken as an example, about posterior one third of the body is separated off as a free swimming individual. The anterior end of this cut off portion is healed up, but no head is developed. Various stages of schizogamy or fission into a sexual and non-sexual zooids have been observed in different genera. In the genus Syllis as soon as the sexual zooid separates, its first segment proceeds to form a head. The asexual portion regenerates the tail segments, the number of which is usually equal to those that were separated. The newly formed segments develop sexual organs and take on the characters of the reproductive bud, which in its turn separates. In Autolytus the sexual zooid develops its head before it separates from the asexual portion, so that the animal now consists of two worms, each with its own head separated by a zone of budding. In some species not only is the hinder part of the body converted into a sexual zooid, which develops its head, but before separation takes place the budding zone continues producing a number of buds from behind forwards, each composed of a number of newly formed segments and the head, so that the whole worm may appear as a chain of as many as 16 zooids, the hindermost being the hinder part of the parent. The zooids attached to the parent develop genital organs, but they are only of one sex for a given stock, the males differing in several essential characters from the females. An extreme case of this gemmiparity or association of buds in a chain is shown by Myrianida. The normal zone of proliferation at the hinder end of the body produces a large number of new segments, the anterior of which becomes a head and thus a new zooid is formed. The zone of proliferation immediately in front of the new zooid now produces another set of new segments and a second zooid results. The process goes on till a large number of zooids is produced, the oldest of these being the most posterior and the youngest next to the parent. In each zooid again there is a zone of proliferation at the hinder end which adds to the number of segments. As we pass backwards, the zooids increase in size. As many as 29 new zooids may be formed in this way forming a chain behind the parent. When each zooid is completed, genital organs are developed and when these are ripe the zooid separates and leads an independent existence. The sexes are separate as in Autolytus. In some cases as in *Trypanosyllis crosslandi* a ventral cushion is formed at the junction of the posterior sexual zooid with the parent individual, and from this a number of secondary sexual buds arise. In *Syllis ramosa* there is lateral branching. A new segment is intercalated betwteen the old segments and from this a pair of lateral buds arise, which develop a head at the end away from the main stem. From the above survey of facts it would appear that fission and budding in the aquatic Oligochaetes and Polychaetes take place nearly in the same way. In

Autolytus and Myrianida where the number of zooids associated with the parent is large, the segments of which they are composed are all newly formed. The zooids are produced so rapidly one after another, that in order that their development be completed they remain attached for some time. The genital organs are to be developed and ripened before separation can take place. But this is not the case in Syllis, and some species of Autolytus and many Naididae where gemmation does not play so important a part as fission. In Nais, Stylaria and some other genera the individual may sometimes consist of three zooids, but in Chaetogester and Aelosoma the number of zooids is much larger. We have seen that in Polcyhaeta the budding is associated with sexual reproduction. In sexual buds the pharynx is not developed. The adaptation of a sexual zooid is not for a long life, but for the dispersal of species. The specimens of *Dero limosa*, *Haemonais laurentii* and *Nais pectinata* show a curious degeneration of the alimentary canal in advanced stages of sexual maturity. There is no mouth opening; the buccal cavity and pharynx are represented by a degenerating mass of cells; the lining epithelium of the gut is also highly degenerate and there is no regular continuous lumen. A somewhat similar condition has been described in several families of the Polychaeta. In the advanced sexual form of Odontosyllis, Autolytus and Exogone the same condition has been observed. The atrophy of the alimentary canal is not in any way due to a pressure of the genital products. It appears then that death ensues after the full attainment of the sexual phase both in the Naididae and the Syllidae.

The periodical appearance of a sexual phase in the Naididae is attributable to certain meterological conditions as well as to some factors inherent in the species. Lankester first said in 1869 that the sexual period is fixed for each species; for *C. limnae* it is October and for *N. serpentina* June. Semper in 1877 contested this assertion and maintained that there is no fixed season. Sexual reproduction can proceed at any time if proper conditions of food are supplied. He denies that temperature has any connection with it. There is no doubt that his inferences are not correct. Vejdvosky in 1884 concludes from his experiments that the sexual phase can occur before time through external conditions. He shows that if one removes water in which *Nais barbata* live, and if the temperature is lowered in the case of *C. diaphanus*, the worms take to sexual reproduction. The results obtained by Ditlevsen in 1904 at the end of his two years' study lead him to think that different species become sexually mature at different times of the year and that in this as well as in other features, each species behaves in a different manner. He mainly worked on *Stylaria lacustris*, which, as is well known, becomes sexually mature from October to December. He never found this species reproducing sexually at any other time of the year and therefore denied that sexual reproduction is dependent on external conditions. Piguet observed that in none of the species he worked on, was sexual reproduction imputable to the conditions of unfavourable existence. He found many species reproducing sexually in the summer of 1906, which was remarkable for its heat and fineness. and concluded that sexual phase occurs under eminently favourable conditions. My own observations extending over a large number of species lead me to think that the sexual period is fixed for each species and that it occurs when the conditions of temperature and food are favourable. It does not vary in any artificial environment. Whether the sexual phase makes its appearance in spring, early summer months or autumn, it appears to be a measure of protection against approaching adverse conditions, the ova, quiescent or developing slowly within the cocoon, being able to withstand such conditions better than the adult animal. There is a good field for work of an experimental nature to prove this with some degree of certainty.

As has been said above, in the Naididae when an individual divides asexually the budding zone in the middle of the body splits in such a manner that a number of segments produced form the posterior segments of the part in front and the remaining, their number being fixed, give rise to cephalised region of the part behind. The head so formed consists of the prostomium and four segments except in Pristina and Naidium where the number of segments including the prostomium is increased to seven. These segments lack dorsal setæ in some genera; their ventral setæ are also different in size and shape from those of the succeeding segments. In Hæmonais also only five segments are newly formed to constitute the head of the posterior zooid, but as the dorsal setæ begin near the 20th segment a considerable number of segments shed their dorsal setæ about the time of detachment of the posterior zooid. The budding zone occurs after the 35th segment and at this stage the segments 36, 37 and 38 of the old animal, which will become 6, 7 and 8 of the new, shed off dorsal setae to resemble the parent in having its dorsal setæ only from about the 20th segment onwards. Different stages in the evolution of the development of head during self-division have been described already, but one thing remains to be mentioned that is, the process of cephalisation has taken place more than once in the family. It has been observed in Branchiodrilus, where *B. semperi* shows an early condition. *B. menoni* a later, and *B. hortensis* the latest. In the species of Paranais it has been described to occur in various degrees of completeness of the development of the budded segments. *Nais pectinata* shows the absence of a budding zone thus illustrating the primitive condition, which probably does not exist in any other species of this genus, where the condition has reached its last phase, that is the formation of the more or less complete head before the fission takes places. Nais is not closely related to Branchiodrilus, yet the same condition has been reached in Nais as in *B. hortensis*.

The relation of budding zone to the position of the genital organs is a question of no mean interest. The genital organs in the Naididæ are situated in the 5th and 6th segments and we know that five segments are produced in the budding zone. In Pritina and Naidium, where 7 new segments are formed in this way, the genital organs are, however, developed in the 7th and 8th segments. The testes and spermathecæ are formed in the last segment derived from the budding zone, i.e., segment 5 in Nais, Hæmonais, stylaria, Dero, etc., or segment 7 in Naidium and Pristina. There is thus a connection between the genital organs and the cephalised segments and what the nature of this connection is we see by the study of the development of the cephalised region in asexual reproduction. The zone of budding is a visible expression of the great activity of the ectoderm taking place at a fixed portion of the body. The ectoderm here becomes thickened owing to the rapid multiplication of cells. In *Stylaria lacustris* in the budding zone two parts are distinguishable in sections—the anterior part, where the proliferation of ectoderm cells is actively taking place to produce a number of ventral setæ and a small posterior part where the head segments of the second zooid are in the process of being formed. These two parts are not separated by any transverse partition running across the body cavity as has been mentioned by several previous workers. But they can be distinguished by a small ventral area of the body wall where no such proliferation is taking place. The mouth of the second zooid is formed here. The ectoderm cells migrate inwards along definite paths penetrating through the muscle layer in the form of longitudinal ridges. These rows are not so definitely shaped in some genera as for instance in Dero. Without going further into details it may be mentioned that various stages in the migration and conversion of these cells into peritoneal cells are seen. The epithelial cells of the intestine in the budding zone which are in process of degeneration are also replaced by some of the ectoderm cells migrating into the body cavity. I may say that it is the epidermis of the bodywall in which are contained the embryonic functions of the organs, which find their expression in the budding zone to produce the head of the second zooid and the posterior segments of the first zooid. The question whether the ectoderm forms the mesoderm is of some biological interest because not only does it go against the fact of early segregation of cells and germ layers in embryonic development, but it also shows that the genital organs arising from the peritoneum formed in the last head segments owe their origin to the ectoderm cells which proliferated in the budding zone. Semper in 1876 described the formation of the new mesoderm from the ectoderm in the budding zone of Nais. Bülow in 1883 found also the same condition in regeneration of the tail of Lumbriculus. Michel, Hepke and Wagner from the study of the origin of regenerated head in Tubifex concluded that the new pharynx arises from the anterior part of the endodermal gut, nervous system from the proliferating ectoderm, setal sacs from ectodermal pits as in the embryo and the new mesoderm, i.e. new muscles and peritoneum from the proliferated ectoderm cells. According to these authors regeneration of the new tail takes place in much the same way. The same organ, then may arise in the same animal from different germ layers. This result has a great bearing on our ideas concerning the value and meaning of the so-called germ layers But Rudolph, who studied the regeneration in Lumbriculus in 1891 and 92 derives mesoderm from specialised peritoneal cells called neoblasts. These neoblasts are distinguished from the ordinary peritoneal cells by their large size. Soon after the fission of the worm they begin to divide in the cut somite and give rise to the greater part of the tissue that later on becomes differentiated into mesoderm. These cells are regarded as specialised embryonic cells set apart for the rapid formation of new mesodermic tissue which arises upon the fission of the worm. Their number is larger in Naids where the formation of new tissue is much more rapid than in Lumbriculus. Ivanhow in 1903 and Krecker in 1910 and 1923 follow Rudolph in demonstrating that the neoblasts form the mesoderm of regenerated segments in Lumbriculus, Tubifex and Limnodrilus. Krecker even goes so far as to say that they stimulate the ectoderm to regenerative activity. According to him these cells lie on the ventro-lateral region of the septa and that there is some connection between the nerve cord and their activities as they migrate along the ventral nerve cord. Dehorne in 1916 derives the new peritoneal cells from the peritoneal cells of the adult. I doubt whether the so-called neoblasts have any existence. The proliferating ectoderm cells in the budding zone exist in the proliferative, migratory and differentiative phases. The neoblasts might have been mistaken for the ectoderm cells in their migratory phase.

Whether the mesoderm is formed from the ectoderm or the neoblasts, the connection between the position of the genital organs and the newly formed cephalised segments in the budding zone appears to indicate that the genital organs are formed by the newly formed peritoneum. Though generally the sexual and asexual reproduction do not overlap, it has been observed in *Nais eliguis. Stylaria lacustris* aud *Aulophorus furcatus* that the testes are present sometimes in the worms which are reproducing by fission. When sexual reproduction commences, the worms generally cease to reproduce by fission. In a few specimens however, not only were the testes and a sperm-sac filled with sperms in various stages of development present in the anterior zooid, but the posterior zooid also possessed the testes in their usual position. This fact has also been recorded in several other species of Nais. Just before the sexual phase appears, or even when some specimens contain sexual organs, asexual reproduction goes on vigorously in others which have no such organs. It seems that asexual reproduction is at its height just before and even at the time when the sexual phase appears. The ultimate aim at this time being sexual reproduction by as many worms as possible, the number is considerably increased by fission. The same condition was observed in *Slavina appendiculata,* when after a few days of asexual reproduction a very large number of specimens both large and slender were obtained with well developed genital organs So acute is the tendency at this time to develop genital organs that they appear even in the zooids before they are detached. Generally the worms which take to sexual reproduction first are large and stout, but when the sexual phase becomes more common, even the most slender and very small specimens possess well developed genital organs. Sexual reproduction then seems to be the order of the day. It, therefore, follows that the newly formed peritoneum from the active proliferating ectoderm in the budding zone proceeds soon after to give rise to the genital organs, but how it occurs that these organs are localised in a particular segment is very difficult to determine in the present state of our investigations In the Polychaeta the genital organs are as a rule not strictly localised; the gonads are proliferations of peritoneal cells, which originate from the peritoneum covering the blood vessels or the alimentary canal throughout a considerable region of the body. In the Oligochaeta, on the contrary, this proliferation is restricted and the production of genital cells is confined in general to one or two testicular segments and a single ovarian segment in the anterior part of the body. As we know that in the Naididae, sexual organs are developed only once in a year at a period when asexual reproduction is most active and further as they arise by the proliferation of ectoderm cells, the material responsible for localisation must be confined to some cells which give rise to the peritoneum of the segments concerned. Stephenson has shown that in *Chaetogaster orientalis* the genital cells are produced in various parts of the body. "Their production is not limited to the parent animal of the chain, but is spread over the whole series of individuals, and occurs in the youngest members of the chain which are scarcely recognisable as separate entities as well as in the most advanced." All the developing sperm morulae lie on the strands in the body cavity, which occupy the anterior region of young individual behind the primary fission zone, and in the one succeeding this, and is small in the anterior half of the chain. These observations confirm my contention that the production of genital cells being confined to the budding zone or the region very near it, the position of the gonads is in general dependant upon the occurrence and extent of the budding zone. *Chaetogaster orientalis* is probably the only oligochaete worm in which a diffuse production of sexual cells, similar to that of the Polychaeta has been described. But the "scattering of the germ tract" in Chaetogoster is a secondary condition due to the adoption of parasitic habits by the ancestors.

The conception of the "germ track" (Keimbahn) which was introduced by Weismann and which, since then, has had a great influence on the biological thought is familiar to all of us. But we may see how it applies to the facts of regeneration and budding, in consequence of which this idea in its original form was to a certain extent modified. The chief feature of the germ cells contrasted with the cells of rest of the body is that they are not physiologically active during the life of the individual. The somatic cells functioning for the whole of the body are physiologically active, and after a time through chemical limitations become old and die. The sexual cells physiologically virginal are therefore in a position to survive the rest of the body in their descendants after death. The problem of the origin of germ cells in metazoa then is of great importance and whether the Keimbahn is clearly discernible in the early embryonic development of all animals is a matter on which the embryologists are sharply divided. In a number of animals belonging to different groups the germ cells are recognisable at an early stage of embryonic development. Such early segregation of germ cells has been known in Sagitta, in certain Nematode worms, and insects and it has been shown that they are cytologically different from other cells, which give rise to the body tissues. The classic example of this kind of thing is the egg of Ascaris as worked out by Boveri. We are aware of the remarkable phenomenon of chromatin diminution in all the cells of the 16 celled segmenting embryo except one, the primitive germ cell, whose descendants undergo no further diminution and from whom only the gonads are produced, while the remaining fifteen cells give rise to the rest of the body. Hegner, Silvestri and Gatenby have clearly demonstrated the occurrence of germ cell substances in the form of pole granules in ova. In Miaster the nucleus which comes in association with the pole-plasm at the hind end of the egg develops into a primitive germ cell. The same has been observed in a number of other Diptera and certain chrysomelid beetles, where those nuclei, which come into relation with a similar pole-plasm or a group of staining granules become the primitive germ cells. It appears to be a matter of chance which of the segmenting nuclei come into connection with the granules, and Hegner showed that by destroying the granules with a hot needle in the fresh egg, embryos without germ cells were produced. In Cyclops and other Copepods Amma has described a cloud of staining granules called ectosomes at one pole of the first segmentation spindle of the egg which about the sixth segmentation division become evenly spread through one cell and when this cell divides, are equally distributed to both daughter cells i.e. primitive germ cells. Even though the Arthropoda and Nematoda furnish many remarkable examples of 'germ track' determinants, we must remember that in many animals even of these groups such substances are not found. In Vertebrata nothing like germ cell determinants has been described in embryonic development. Even whether the germ cells arise early in embryo formation is disputed by a large number of workers. One group of observors claims to have traced the germ track from early stages and denies that peritoneal epithelial cells could metamorphose into cells which ultimately give rise to eggs and spermatozoa. The other group of workers such as Waldeyer, Balfour, and Gatenby deny that an early seggregation of germ cells takes place and consider that germ cells are formed by the germinal (coelomic) epithelium. In Polychaeta it is well known that the germ cells arise periodically from the peritoneum covering in many cases nearly the whole of the coelomic cavity. But the origin of mesoderm or peritoneum can be traced in early embryonic development from one or two definite cells, which do not show any histological difference from the remaining cells at that stage. In Oligochaeta the production of genital cells, though restricted in general to one or two segments, takes place from the peritoneum on the posterior face of the septum concerned. In the Naididae as suggested above they arise from the newly formed peritoneum originating from the ectoderm in the budding zone. This corresponds more or less to what has been described in the Syllidae, where it has been long known that budding is associated with sexual reproduction. The connection of sexual with asexual reproduction in the Naididae was not recognised before, because the reproductive organs make their appearance generally after the worms have multiplied by fission.

Gatenby tries to explain the presence of germ track determinants in the eggs of insects as due to the specialised character of the group, where the developmental history is much modified. The egg is to develop into a larva very quickly within a certain time and season, therefore the germ cells must be provided with some sort of food "to keep them either independent of the already occupied somatic cells or to enable them to go on with their development synchronously with the somatic cells." The determinant granules are regarded as substances, which are of a nutrient nature. The somatic cells provided with yolk are kept apart from the germ cells, so that the latter are not caught up in the differentiating process and if they do the animal would become automatically sterile. So in certain animals the distinction between soma and germ track as provided by Weismann holds true and in these the adult does not possess much capacity for regeneration or budding, though the embryonic tissue in some cases undergoes a process of fission giving rise to a number of embryos. In *Litomastix*, one of the parasitic Hymenoptera, the egg before maturation contains a chromatinic compact body called oosoma which passes into one of the four cells into which the egg segments. When this cell divides, the oosoma enlarges, breaks up and is equally distributed to both daughter cells. As these cells divide to form a mass at the anterior end of the embryo, all the cells contain a portion of the oosoma. The mass of embryonic cells breaks up into a number of morulae, each developing into a larva. So hundreds of larvae are produced from each egg. Some are normal having gonods, others are sexless being devoid of gonads The sexless larvae do not develop into adults and Silvestri regards them to arise from the masses of cells, which do not receive the primitive germ cells containing oosoma. One should consider polyembryony (embryonic fission) to occupy a more or less parallel position to the asexual reproduction by fission if we suppose that ordinary body cells might retain sufficient germplasm to enable them to regenerate lost parts or even to produce a complete individual. One may go so far as to say that adult animals, capable of reproduction by budding or fission, contain a great portion of embryonic tissue in their make up with adult characters imposed on it. In animals where differentiation into somatic and germ cells has taken place early in development, the capacity of reproduction is restricted only to germ cells. The differentiation may be visible very early in the form of determinant granules in the ova, or the differentiation may be there though it is not histologically apparent as in vertebrates and many annelids. It appears that we cannot escape accepting Weismann's modified conception of germplasm in its general form and we may see whether there is any evidence to support it from the study of experimental embryology.

Fission and budding, the usual mode of reproduction in certain Polychaetes, Oligochaetes and Turbellaria can be brought about under experimental conditions in the embryonic stages of animals in which it normally does not occur. Not only do adult animals have power of regeneration, but embryo and larval forms possess the same, and in many cases portions of segmenting eggs may be able to produce complete organisms. Roux was the first to demonstrate that by destroying one of the first two blastomeres of the frog's developing egg a half embryo was produced, which regenerated the missing half. He explained that the uninjured blastomere first gives rise to a half embryo and then the formation of new cells takes place in the injured half by a process of reorganisation, which is set up after a few cells from the uninjured half have migrated into it. Endres and Walter re-examined the process and confirmed Roux's results that the reorganising cells migrate from the uninjured to the injured side and around them the protoplasm of that side makes new cells. When the injured material is completely worked over, a complete embryo is formed. The typical half embryos by Roux were also obtained by these authors. Hertwig denied that the injured blastomere is dead, but on the other hand considered that it exerts an influence on the other half. He suggested that if the injured half is removed, the uninjured blastomere would produce an entire embryo, which would differ from the normal embryo only in size. Herlitzka separated the first two blastomeres of the salamander's egg and found that each blastomere gave rise to a perfect whole embryo of half size. This supports Hertwig's view that the power of producing the whole embryo is also present in each of the first two blastomeres of the frog's egg. Driesch's experiments on the eggs of sea-urchin are well known. He found that when the first two blastomeres of sea-urchin egg were separated from one another by violent shaking or by excluding lime from the artificial sea water, each developed into a perfect larva of reduced size. He also showed that one of the first four blastomeres and in a few cases one of the first 8 blastomeres would develop into a perfect larva. If sea-urchin blastulae be cut into pieces, these pieces if not too small will develop into gastrulae and then into the pluteus larvae. Before the gastrula is formed, mesenchyme cells are budded from the lower pole into the cavity of the blastula. If the blastula be cut into pieces after this has occurred, these pieces may still heal up and develop into miniature blastulae, but only blastulae derived from the lower pole of the original blastula will develop into gastrulae and form guts, while those derived from the upper pole do not develop further and die. If the gastrula of the starfish after it has got a thin walled vesicle, which gives rise to the coelom is bissected, so that one piece does not contain the vesicle, this piece will develop into a miniature gastrula, which will never form a coelom. Driesch, however, got different results from his work on the ctenophore Beroe. If one or two cells in the segmenting ovum consisting of eight cells are removed, the remainder will develop into an imperfect ctenophore with 6 or 7 instead of the usual 8 ciliated ribs. It is then clear that the material for one particular rib must be localised in a particular blastomere. It was found that this specialisation even existed before the egg had segmented, for when pieces of protoplasm from unfertilised eggs were cut, the eggs developed into ctenophores with an imperfect number of ribs. To explain these results Driesch assumed that the living material left after the removal of a part so arranged itself as to produce the entire animal. The larva has some sort of polarity which to some extent is independent of the character of separate cells of which it is composed. The presence of this polarity or arranging spirit he called 'Entelechy.' Where the complete animal was not produced as in the ctenophore egg *i.e.* where a larva with an incomplete number of ribs was obtained, the protoplasm had become precociously stiffened or differentiated so that when a part of the egg was removed, the organs to which it was to give rise were not developed. The egg of the mollusc Dentalium has a broad equatorial band of reddish pigment with small white anterior and posterior polar areas. When the egg is divided into equal cells, the posterior white area remains undivided, but becomes a yolk lobe attached to the two cells. Wilson found that if before segmentation this white area is cut off, no yolk lobe is formed and in the resulting larva both the post-trochal region and the apical tuft of cilia are absent showing thereby that the part of the egg which develops into yolk lobe determines the production of parts at opposite ends of the larva. Wilson got similar results in some other molluscan eggs. When the segmenting molluscan egg was kept in sea water free from lime, it broke up into its constituent cells like the sea-urchin egg and when these cells were placed in ordinary sea water, they did not produce miniature complete embryos, but on the contrary each developed into a part of an embryo. Now these facts led to the discovery of organ forming substances, which were observed by Conklin located in various regions of the egg of the mollusc Cynthia for formation of the organs. The investigations of Hirschler, Duesberg Gatenby and others on the cytoplasmic inclusions show that the so-called visible organ forming substances are the mitochondria, Golgi bodies and a certain amount of yolk in different regions of the egg. Obviously these substances are not the cause of specific differentiation. Though the eggs of starfish, sea urchin and some other animals are apparently quite undifferentiated in early periods of development, it is not true of the eggs of early embryos of many other forms. We have seen that this appears to be the case in such highly specialised eggs as those of ctenophores, molluscs and nematodes. In Beroe and Dentalium the removal of part of the egg before segmentation causes the larva to be defective. The most important outcome of these experiments is that there is a certain amount of independent power of development in the parts of the egg. In these cases the parts are determined very early in the egg even before it segments and possibly there is a localisation of some kind of substances responsible for their development.

But there is no visible indication of the existence of such substances, which we can detect with the reagents and magnifications at our disposal. Weismann's theory of germplasm assigns differentiation of cells to the qualitative divisions of the nucleus so that the chromosomes of the two daughter cells are in some way unlike. But there is little evidence for such differential nuclear divisions. He based this hypothesis on the score of experimental results obtained by Roux. In order to explain Driesch's results in sea-urchin eggs *i.e.* two or four blastomeres into which the egg segments produce two or four larvae, he assumed that in addition to the chromatin taking part in the early qualitative division of the nucleus there is contained some kind of reserve germ-plasm, which becomes divided at the ensuing cell division into each daughter cell. So each cell in this way may contain the potentialties of the whole egg. The reserve germplasm may be awakened by any stimulus that alters the normal development as for instance when the blastomeres are separated. The hypothesis was applied to explain the phenomena of regeneration and budding, according to which all the regenerative capacity is supposed to be contained in the nucleus, the cytoplasm being left out of account. Wilson's well-known experiment on the eggs of Nereis shows that the nuclei, which would have normally become those of ectoderm cells can be made to belong to endoderm cells if the egg before segmentation is subjected to pressure between glass plates. All the three cleavages that take place are vertical and the cells produced lie in one plane; the consequence is that all the eight cells contain oil drops. They are so to say endodermal, while normally the third division separates four large endodermal from four small ectodermal cells. It follows that the nuclear divisions do not in any way cause the differentiation of cells. Moreover we know that during cell division the chromatin divides exactly into equal parts, while the cells arising as the result of division play altogether a different part in subsequent development. The nuclei produced by the division of the egg-nucleus are potentially alike and it is not the nucleus but the cytoplasm which undergoes differentiation. Mac Bride considers the budding or regenerative capacity to be due to a renewed activity on the part of the nuclei in producing organ-forming substances. Why the bud is developed in a different way from a fertilised egg he explains on this hypothesis. In the development of the bud of Ascidians, the central nervous system arises from the pharyngeal wall, whereas in embryonic development it arises from the ectoderm. In the bud, the ectoderm being an extension of the maternal adult ectoderm is composed of specialised cells for the production of cellulose and cannot possibly be made to develope a new organ, for the cytoplasm is so specialised that it can not be modified into new directions, though the nuclei may have the capacity to produce these substances. In the budding of naids we have seen that the ectoderm is the most active layer producing all the organs and the peritoneum from which the genital organs arise. Certain cells of the epidermis in the adult worm, though it does not indicate any sign of fission, are generally in a state of mitotic division. It shows that the cells of this layer contain very active nuclei. Mac Bride's view that the organ forming substances are chiefly poured by the active nuclei into the cytoplasm of the cells giving them the power of forming organs assigns a passive role to the cytoplasm in the development and differentiation of organs. It places the cytoplasm in the position of a mere medium in which the nucleus carries on its activities. But the nucleus and protoplasm are parts of a living whole. They cannot act independently; on the other hand by interaction that takes place between them each is more or less modified by the other. If organ-forming substances are formed at all, they are produced by the interaction between the nucleus and cytoplasm. When we know that the capacity of reproduction by budding or regeneration is in general limited to animals of lowly organisation, it can safely be concluded that not only the nucleus but also the cytoplasm is capable of taking full share in the process. The cell as a whole, embryonic or unspecialised in its constitution as it is, is renewed into activity. Such undifferentiated cells have a small amount of cytoplasm surrounding a fairly large nucleus. They probably possess the kern-plasma relation which is characteristic of the active embryonic cells. The presence of these substances, however, has never been detected. There are a few striking cases, which can be explained only on the assumption that the development of one organ is dependent on the existence of the other possibly through the organ forming substances which its cells emit. Herbst found that if the eye stalk of a young schrimp be removed, it will regenerate a new one. But if the optic ganglion of that side is also removed, a new antenna will be produced and not a new eye. It can, therefore, be concluded that the ectoderm which develops into the eye does so under the influence of the optic ganglion. Lewis slit open the skin of a young tadpole of newt and cut off the optic vesicle. When the wound was healed, no lens was formed by the ectoderm. When the optic vesicle was cut off from the brain and pushed back under the skin in a hinder region of the body, the rudiment continued to live and grow in its new position and made the skin covering it develop into a lens, although this skin in the history of the race never produced a lens before. Now these results cannot be explained by Weismann's hypothesis. The influence or stimulus of the developing optic vesicle makes the ectoderm adjacent to it develop into lens; so we find that organs are thus developed under the influence of other developing organs. How it happens we do not know. Though once the theory of organ-forming substances brought near the possibility of solution of the problems not only of experimental embryology, but also of regeneration and budding, no further progress has been made to put this theory on a demonstratable basis, and it must be admitted that we are yet in the realm of speculation about these substances. We see that a study of regeneration, asexual reproduction by budding and fission, polyembryony and experimental embryology passes into cytology. They open a large number of interesting questions, which provide a fruitful field for research.

Abstracts of Papers.

1. A short note on the distribution and habits of *Balwantia soleniformis* Benson.—*By* SUNDER LAL HORA.

This interesting bivalve lives in burrows excavated in either hard blue clay or in friable sandstone. The species was found to be quite common in the Daleswary and the Barak rivers in Cachar and from observation made in the field it seems quite probable that on a proper search being made it will be found to be widely distributed in the Surma Valley.

The animal lives in a burrow firmly anchored by its foot at the anterior end. It is able to enlarge its burrows by a to and back movement caused by the expansion and contraction of the foot. The coarse longitudinal ridges on the shell and its sharp margin help in the process of excavation. In captivity the animals showed no movement. This fact and several other observations have convinced the author that the animal is not able to start fresh burrows, but enlarges those which are already present according to its requirements.

The Uriya coolies consider the animals of this species as a great delicacy and have devised a nice instrument for dislodging these bivalves from their burrows.

2. On some more Gregarine parasites of Indian Earthworms. —*By* B. L. BHATIA *and* SAM B. SETNA.

Ghosh (1923), Bhatia (1924), and Bhatia and Chatterji (1925) have previously described a number of monocystid parasites from Indian earthworms. A complete list of the hosts examined so far and the parasites described from them is given in the paper mentioned last.

In the present paper some more monocystid parasites are described from the seminal vesicles of various earthworms from Kasauli and Bombay not examined before. The following is a list :—

Monocystis mathaii sp. nov., from *Megascolex trilobatus* (Steph.) from Bombay.

Nematocystis stephensoni sp. nov., from *Eutypheus incommodus* Beddard, from Kasauli.

Stomatophora bulbifera sp. nov., *Rhynchocystis mamillata* sp. nov., and *Rhynchocystis awatii* sp. nov., from *Pheretima elongata* (E. Perr.) from Bombay.

M. matthaii recalls the form of *M. villosa,* but differs from the latter in not possessing a hairy covering. Solitary encystment and occurrence of cysts containing three individuals has been noted. All the three associants contained fully developed spores. Worms from Lal Bagh (near Parel, Bombay) were highly infected, but the same worm from Charni Road garden (another part of Bombay) were not infected at all.

Nematocystis stephensoni has a peculiar nuclear structure. The full life history of this organism has been studied.

Stomatophora bulbifera has an inverted balloon shaped depression at its anterior end.

Rhynchocystis mamillata is characterised by the possession of a nipple-shaped mucron, and *Rh. awatii* has a cylindro-conical epimerite marked by longitudinal epicytal striations.

3. Notes on some more fresh-water ciliates from Lahore.—*By* B. L. BHATIA *and* B. K. MULLICK.

Bhatia (1916, 1920, 1922) has previously published his observations on the fresh-water ciliates of Lahore and recorded *41* species, of which *39* had been recorded for the first time from any part of India. Bhatia and Mullick read a paper on the fresh-water ciliates of Srinagar (Kashmir) at the Science Congress at Benares, recording *18* species of which as many as 17 species had not been recorded from any part of India before.

The present paper deals with *10* species of fresh-water ciliates examined at Lahore, which are all recorded for the first time from any part of India. A few of these are new species.

4. Life history of *Bufo melanostictus* Schneider.—*By* A. KUMAR *and* H. S. SODHI.

The paper first describes briefly the act of oviposition in this toad and then deals with the life-history of the animal.

The more important points relating to the life-history of this toad are as follows. The segmentation of the egg proceeds very quickly; the first cleavage of the egg takes place in an hour after fertilization and the next two divisions by the end of the 2nd hour. Segmentation is completed by the end of the 6th hour and the blastopore makes its appearance during the 7th hour, the medullary plate is visible during the 20th hour and soon after this the cement organ makes its appearance. The embryo hatches out by the 24th hour after fertilization and at the time of hatching is at a much lower stage of development than in the case of Rana. The embryo is helpless at the time of hatching, the buds of the external gills make their appearance about 14 hours after hatching and it is not till the day after, *i.e.* more than 48 hours after fertilization, that the external gills become branched, and the larva is converted into a typical tadpole. The development from now onwards proceeds in the usual way when, at the end of 3 weeks after fertilization, metamorphosis takes place.

Another feature in which *Bufo melanostictus* differs from *Rana temporaria* in its development is the fact that the lower portion of the blastopore never closes up but persists throughout life as the anus. The life-history of *Bufo melanostictus* shows 3 characteristic features, viz. (1) the rate of development is very rapid the whole life-history taking only 3 weeks for its completion, (ii) the larva hatches out at a stage very much earlier than in the case of *Rana temporaria*, and (iii) the lower portion of the blastopore persists as the anus.

5. Notes on the anatomy and histology of *Virgularia gracillina* Kölliker from Chilka Lake.—*By* CH. ABDUL HAMID.

On a previous occasion (January, 1925), the author submitted a preliminary account of this species. Since that time the species has been properly identified and studied in detail. In the previous account some mistakes had crept in, which the author is now able to correct. The spicules are absent only from the rachis but present in the peduncle. The Siphonozooids are 4 in number, and situated in a somewhat semi-circular manner on the "Ventral track" between the leaves. The Radial canals are arranged in a dorso-lateral row on the pararachis.

Notes on the anatomy and histology of the species are also added.

6. Notes on a new species of *Dichelaspis*.—*By* CH. ABDUL HAMID.

In November, 1924, the Zoology Department, Government College, Lahore, received a number of Crabs from Karachi. On dissecting open the respiratory chambers, it was found that the gills and the respiratory appendages of the majority of these crabs were beset with small specimens of a species of cirripede. These cirripedes seem to constitute a new species whose principal characters are as follows :—

Valves three, appearing like five on account of the scuta being divided up into 2 parts. Terga altogether absent. Carina with a well developed "mid rib" and a cup like basal end. The valves do not approximate. Mandibles support 4-5 principal teeth, the 4th and 5th in some cases being notched. Maxilla supports 8 long spines and is not notched. Anterior and posterior rami of the first pair of cirri equal in length and thickness, caudal appendages uniarticulate. Penis is proboscis-like and spinose. Filamentary appendages absent.

7. Taxonomic work on Sea anemones of the Karachi coast. —*By* BAWA BALWANT SINGH.

The author has been carrying on work on the collection of sea anemones he had made at Karachi. The collection contained about 700 specimens. The author has cut several sections of specimens of most of the genera and examined both their external and internal characters. 10 genera and 14 species are found represented in the collection of which 5 genera and 12 species appear to be new.

8. Notes on breeding habits of the common Earwig, *Anisolabis annulipes* of Lahore.—*By* RAM NATH.

The time of oviposition and hatching ranges from the middle of March to August. The larva emerges at the end of 13 days, having a general resemblance to the imago, but this period varies with the condition of warmth and moisture. There appear to be four successive moults before the condition of the adult imago is reached and each instar lasts about 11 days except the first. Observations on the manner of increase and variation of the antennal segments are also recorded.

9. On the histology of the Malpighian tubules in Myrmeleon and Cockroach.—*By* KARAM SINGH.

The malpighian tubules in the adult condition in Cockroach and *Myrmeleon*, though believed to perform the same function, show certain notable differences in their histological structure. The chief contrasting characters are the number, size and arrangement of the tubules, the cell outline, the size and shape of nucleus and the dimensions, form and location of the excretory concretions. In the adult *Myrmeleon* the arrangement of tubules in relation to the alimentary canal is slightly different from that found in the larva. The tubules in the larva of *Myrmeleon* secrete a sticky material, which is used in spinning the cocoon in which the larva pupates.

10. On the fresh-water Entomostraca of Lahore.—*By* G. L. ARORA.

The writer has been engaged in working out the fresh-water Entomostraca in and around Lahore with special reference to Cladocera. Collections of water containing these animals have been made from sixty different localities within a radius of nearly 5 miles from the city. The author has so far found altogether 14 different species of Entomostraca of which the *Cladocera* claim five genera and seven species and the Ostracods two genera and four species.

Among the Cladocera 2 genera appear to be new to science, whose characters are as follows :—

1. Belonging to the *family Daphnidae*—Rostrum and cervical sinus are present. The valves have distinct and definite pentagonal and hexagonal markings. The ocellus is round.

2. Belonging the *family Daphnidae*—No rostrum, antennules large and freely movable. Valves elliptical covering the body, ocellus is absent, abdominal process represented by a horse-shoe-shaped fold. This combines the characters of the genera Moinodaphnia and Moina.

The other genera are *Daphnia*, *Moina* and *Oxyrella*. The species belonging to the genus Daphnia are *D. psittacea* Baird; *D. longispina* Leydig and *D. pulex* de Geer.

The species belonging to the genus Moina is new, the characters of which are as follows:—

The animal is transparent, head large, nine ciliated post-anal spines with a bident, no supra-occular depression, claws pectinate.

The species belonging to Oxyrella is *O. tenuicaudis*.

Among the Copepods the three genera so far found are:—*Diapotomus*, *Cyclops*, *Cetochilus*.

Among the Ostracods the two genera found are:—*Candona* and *Cypris*.

11. An account of the butterflies of Lahore.—*By* DEV RAJ PURI.

The paper deals with a collection of butterflies of Lahore made with the view of studying problems of Mimicry and Colouration. Butterflies were also collected from Pusa, Dehra Dun, Karnal and Mussoorie.

In all 150 different species were collected, of which 50 belonging to five families were from Lahore.

A number of well-known instances of protective colouration were met with, but mention is made here only of such instances as are not commonly known. These are (1) *Melantis ismene* Cramer, (2) *Junonia orythia* Linn. (3) *Catopsilia crocale* Cramer.

Cases of Mimicry which appear to the author to be new are met with in the following cases:—

	Model.	Mimic.
(1)	♀ *Delias eucharis*	♀ *Pareronia hippia.*
(2)	♀ *Ixias pyrene*	♂ *Huphina nerrissa.*

12. Fresh-water Nematodes of Lahore.—*By* KISHORI LAL BHATIA.

Practically no work has been done on fresh-water Nematodes in India before. A large number of specimens collected from various localities in Lahore, are all referable to a single genus, *Dorylaimus*. Probably several species are represented among the specimens. Sexual dimorphism occurs.

13. The trematade parasites of *Rana tigrina* of the Family Pleurogenetinae Luhe.—*By* H. R. MEHRA *and* PRATAP SINGH.

(1) *Pleurogenes prayagi*, sp. nov. is found in the posterior part of the small intestine and sometimes in the rectum. The parasite is fairly common, one out of every five frogs being infected with it.

Distinguishing characters:—Ventral sucker slightly larger than the oral. Alimentary system with a small prepharynx, moderately long intestinal caeca with swollen hinder ends reaching as far back as the posterior 4/5th part of the body. Excretory bladder Y-shaped. Two testes of a spherical shape, situated one behind the other, lie anterior to the ovary and the ventral sucker. The vitellaria cover the intestinal caeca except the anterior and the posterior small portions. A large receptaculum seminis with a Laurer's canal present. Vesicula seninalis large and coiled; Cirrus sac absent.

Some interesting features in the anatomy are described and systematic position discussed.

(2) *Pleurogenes medians* Looss. var. equalis, var. nov.

Only four out of 89 frogs were found infected with it.

Salient features in the anatomy are described. It differs from the type species in the form of the body and equal size of the two suckers; by the absence of the prepharynx and oesophagus.

(3) *Prostocus confusus*, var. indiana. var. nov.

Found in the duodenum; only 8 out of 89 frogs were infected with it. Important features in the anatomy are described. It differs from the type species in the length of the intestinal caeca, which reach here the middle of the body. Testes do not lie at the same level. Ovary lies at a level with the ventral sucker, but not anterior to it. A large portion of the cirrus sac lies anterior to the intestinal caecum and only a very small portion behind it; the vesicula seminalis is larger.

14. Probable stages in the life-history of *Tremiorchis ranarum* and some Cercariae found in the common fresh-water snail.—*By* H. R. Mehra *and* Pratap Singh Negi.

Rana tigrina—the host of *Tremiorchis ranarum*, *Pleurogenes prayagi*, *Pleurogenes medians* and *Prostocus cofusus* feeds on *Vivipara bengalensis* and *Indoplanorbis convexiusculus*, the common fresh-water snails found at Allahabad The living snails were obtained and examined for Cercariae.

In *Vivipara bengalensis* fully developed cysts containing immature Trematodes are found in the gills and mantles. They are elliptical in shape and white in appearance. In the mantle there occur besides the mature cysts young stages in their development. The fully developed cysts contain a small lively Trematode with two suckers and a club-shaped excretory bladder which reaches near the ventral sucker. The body is covered with small spines.

In *Indoplanorbis convexiusculus* immature cysts are found in thick pigmented wall of the body, which is capable of coming outside the shell, and the mature cysts in the coils of the intestines, albumen and hermaphrodite glands. In addition these snails have been found to be infected with the following different species of cercariae: (1) Amphistome cercaria Group pigmentata, (2) Distome cercaria of Tremiorchis ranarum, (3) Stylet cercaria, (4) Lophocercus, (5) Two species of Furcocercous cercariae. The structure of these cercariae is described. It is believed that the distome cercariae (2) develop into young distomes found in cysts. One snail is infected with one kind of cercariae only at a time. The work is in progress and experiments are being made.

15. On a new Species of Opisthorchis from *Rita rita*.—*By* S. C. Varma.

The Trematode occurs in the gall bladder of the Siluroid fish, *Rita rita* obtained locally.

The fully developed specimens have a yellowish brown colour about the middle of the body and are almost transparent. Length varies from 4 to 7 mm, and breadth from 1 to 1·2 mm. Body uniformly spinose and divisible into three regions. The anterior sucker is slightly smaller than the ventral, but in young forms the condition may be reversed. The oesophagus is about as long as the pharynx, and the intestine terminates near the posterior margin of the hinder testis. The testes lie in the posterior part of the body obliquely one behind the other; the ovary situated on one side of the median line is usually circular and a pear shaped receptaculum semenis and Laurer's Canal are present. The uterus is transversely coiled and situated in the middle of the body. The vittelaria are confined to the sides of the same region. The genital pore lies close in front of the ventral sucker, which is capable of being protracted by the animal into a process or pedicle. The excretory bladder is S shaped and distinctly horned in front of the anterior testis.

This genus includes a large number of species mentioned by Stephens, Brumpt, and Braver, etc., which occur only in mammals, Reptiles and Birds; Odhner has, however, described one species from the gall bladder of a Nile fish, and this is another species obtained from Pisces.

16. On a new Cestode from *Rita rita.*—*By* S. C. VARMA.

The Cestode occurs in the duodenum and small intestine of the Siluroid fish, *Rita rita*, and has not so far been found in any other fish.

The length of the tape worm varies from 25 to 50 inches, and perhaps even more. One specimen measured 42 inches long. The head is about 1·5 mm in diameter, and bears 4 unarmed suckers and a sucker like pigmented organ in place of the rostellum. The neck is very long and narrow, the proglottids number several hundreds, and gradually increase in size behind. The genital pores alternating irregularly, are situated somewhat in front of the middle of the lateral margin. The genitalia is single, and the vagina is always anterior to the Cirrus-sac.

The infection is not very common, about 10 p.c. of the fishes examined carried the worm.

17. On the structure and bionomics of a fresh-water Turbellarian belonging to the Sub-order Acoela (Uljanin).—*By* S. K. DUTTA.

A large number of the Turbellarians were obtained by Dr. H. R. Mehra, from a pond in the neighbourhood of Benares, and through his courtesy I obtained all the specimens, the anatomy of which has been studied and described.

The Turbellarians were obtained along with aquatic Oligochaetes from the mud and weeds. They are usually obtained in large numbers from November to January.

The size is small, the length varies from ·75 mm—2·5 mm and breadth from ·8 mm—1·2 mm (spirit specimens).

The mouth is situated on the ventral side about 1/3 from the anterior end. It leads into a muscular pharynx which is circular in shape. The pharynx leads into the parenchyma directly—there being no enteric cavity.

The genital organs are described. The genital pore is not far behind the mouth and is single. Being monogonoporous it appears to belong to one of the genera of the Family Proporidae. The work is proceeding and proper identification will shortly be made.

18. On a new Cestode from *Wallago attu.*—*By* DHARAM NARAIN.

The Cestode occurs at all times of the year in the small intestine of *Wallago attu* one of the commonest fishes of Allahabad. It has not been observed so far from any other fish. The length varies from 4 to 6 c.m. The number of proglottids is about 60 to 70. There is a distinct head with four unarmed suckers and a rostellum with a row of spines around it. A single set of reproductive organs is present in each segment. The genital pores are marginal and alternate irregularity.

The position of the two orifices, *i.e.* of the cirrus and vagina alternates, sometimes the former is anterior and sometimes the latter, as has been described by Beddard in certain Icthyotaenia from reptiles.

Southwell has described a Cestode from the same fish which is totally different.

19. Preliminary observations on the general habits and the so-called poison glands of *Scolopendra morsitans* L.—*By* L. P. MATHUR.

1. Scolopendra is common in Agra and the neighbourhood. April, May, and June are the best months for studying its habits. During these months they are very active and one could collect specimens almost to order. This is the breeding season as well. I have collected eggs in the month of June.

2. There are big gaps in our knowledge of the breeding habits of this centipede. The accounts given in various Text Books are superficial and sometimes contradictory. I have been trying to study the breeding habits of Scolopendra for some time and I have not yet had much success in this direction.

3. They can live in captivity for months. I have at present a number of these centipedes with me for over six months. They thrive on earthworms and Coconut (Kachha). After every meal the centepede becomes rather sluggish and lies snug under pieces of bricks in the jar.

4. The effect of Centipede bites :—A number of unauthorised yarns regarding the poisonous character of the centipede bite are repeated and with the single exception of Cornwell hardly any efforts have been made to chronicle facts concerning the centipede bite, and its poisonous character.

The centipede is very voracious though hardly vicious When hungry it will devour its own kith. I induced my specimens to bite a young Lizard, a toad, a frog and a Rabbit, and none of the victims died or suffered much as a result of the bite. During the process of biting a yellowish fluid is secreted, which gets mixed up with the morsel.

5. The effects of the bite in all these experiments were not serious and they all resulted in local, temporary and minor troubles. The so-called poisonous secretion is acidic and is a strong concentrated digestive fluid, which performs a triplicate function. It is mainly digestive, partly offensive and partly it acts as a lubricating secretion.

20. Grassi's disease among Lac insects.—*By* S. MAHDIHASSAN.

One cause of mortality among lac insects is a disease, the characteristic symptoms of which were first reported by B. Grassi in studying the coccid, *Diaspis pentagona* and further confirmed by F. A. Barrætavena and C. D. Girola. Lac insects suffering from this disease contain few or no symbiotic yeast-like organisms. From some a motile bacterium has been isolated which apparently represents antibiosis with lac symbionts.

·21. Dynamics of Lac secretion.—*By* M. SREENIVASAYA.

Lac encrustation consists of a heterogenous mixture of several resins, fatty acids and waxes, each of which is elaborated and secreted by a particular set of glands. The glands themselves are of different sizes and shapes and are attached by means of their slender, sometimes long chitinous ducts to the inside wall of the skin of the insect, allowing the entire gland a free ciliary movement. A common colloidal plasma bathes the whole set of glands which derive their nutrients and precursors of secretion from the fluid by selective absorption at the gland-plasma interface. The periodic shooting forth of the "honeydew" as a result of the pulsating action of the rectum, gives a measure of the intensity of commotion set up in the plasma and the movement of the glands. A few of the important constituents of lac have been detected micro-chemically in the glands and the plasma.

22. Notes on some Indian Lepidoptera with abnormal habits.—*By* T. V. RAMAKRISHNA AIYAR.

1. Instances of Lepidoptera which are subject to the unsolicited attentions of other insects, especially of parasites and predators of sorts, are numerous and quite common all over the world. On the other hand, examples of moths or butterflies which seek the company of other insects and live in association with them appear to be comparatively few; and in some of the known cases our knowledge of the mutual relations between such hosts and guests is also quite imperfect. In spite of these facts, the few Lepidoptera that exhibit such abnormal habits are not uncommon in different parts of India, and observations on their bionomics go to show that some of them are also of economic interest. This paper presents a brief record of some of the observations made by the writer of the bionomics of a few such insects noted in South India; incidentally a few records of such examples noted by others in different parts of India are also included, the idea being to make the whole paper a brief summary of our knowledge of entomophilous or entomophagous Lepidoptera recorded so far from India.

2. Among Butterflies the only recorded example of an aggressive species appears to be the Lycænid caterpillar *Spalgius epius* West. It has been noted in South India as a common predator of some well known mealy bugs which are often injurious to cultivated crops. The common hosts appear to be *Pseudococcus citri* and *Phenacoccus iceryoides*. It's chrysalis is popularly known as the 'monkey face pupa.'

3. Among moths the commonest and the most important are some of the predatory species of the noctuid genus *Eublemma*. The commonest species in South India is *E. scitula*, which is destructive to scale insects of different kinds *Pulvinaria maxima, Anomalococcus indicus* and *Tachardia lacca* being the chief hosts. Bionomical notes on this species are added and its economic importance is explained. What little is known of the habits of the group Epipyropidae is added: this is a small family of moths the caterpillars of which are found living in association with some homopterous bugs—chiefly species of Eurybrachys. The mutual relations between guest and host in these cases are still obscure to correctly indicate the economic importance. A few records of Microlepidoptera are also noted. Among the Pyralidae the wax moth *Galleria mellonella* is well known as destructive to bee hives all over the world. A phycitine caterpillar *Phycita dentilinella* is recorded as a predator on the common South India nettle grub *Prasa lepida* Gr. This latter is often a destructive pest on Mango, Castor and palms and the predatory caterpillar apparently does some good work as a natural check.

Finally some observations made on a recently noted Pyralid *Euzophera cocciphaga* Hare are added. This caterpillar is found in numbers attacking a giant scale *Aspidoproctus xyliæ* n. sp. on the rain tree in the Coimbatore Agricultural College Farm. The dome shaped body of each scale is found invaded by more than one predatory caterpillar and the internal contents-eggs, just hatched larvæ-devoured.

There is no doubt that many more cases of moths or butterflies with these curious habits might exist in different parts of India and may be discovered in course of time. As stated before this paper is just an attempt to invite the attention of entomological workers all over India to this aspect of insect bionomics—an aspect which is not only of biological interest to the pure scientist, but has its own economic importance and value.

23. On the occurence in Calcutta of *Pentatrichomonas ardin delteili = Hexamastix ardin delteili D. et R.* and its method of multiplication.—*By* HARENDRA NATH ROY.

This paper records the occurrence in Calcutta of *Pentatrichomonas ardin deltelli* and its method of reproduction in detail which up to the present was unknown.

24. Local variations of specimens of *Cardina nilotica var. gracilipes.*—*By* P. C. MAHALANOBIS.

The paper gives a biometrical analysis of the number of teeth of specimens of *Caridina nilotica, var. gracilipes* classified under the heads; (i) basal, (ii) apical, (iii) upper border and (iv) lower border. The specimens were collected by Dr. S. W. Kemp from Colombo (Ceylon), Villyayakum (Madras), Garia (Bengal), Port Canning (Bengal) and Baratunga Island (Andamans). A systematic variation which is associated with the geographical locality is clearly indicated.

25. On the sugar-cane root Aphid *Tetraneura Ulmi Coimbatorensis*, Sub. Sp. Nov.—*By* C. J. GEORGE, M.A.

In this paper the Coimbatore sugar-cane root Aphid is described as a new sub-species of the well-known species *Tetraneura ulmi* De Geer. The apterous form is distinguished from the corresponding form of *ulmi* by the smaller size, whiter colour and the four-segmented antennae and the alate form, by the longer antennae having a different number of sensoria on them.

26. A preliminary note on the Binomics of the Pigeon fly, *Lynchia maura* Bigot.—*By* S. R. NAIR.

A preliminary note on the binomics of Lynchia maura, a parasitie fly on the body of pigeons, is treated in this paper. The importance of the fly lies in the fact that it is supposed to transmit certain protozoan diseases (*Hæmoproteus Columbæ*) in pigeons. Observations regarding the distribution and habits of the fly, which are to be considered before studying the diseases transmitted, are recorded.

A method is devised for feeding these flies.

Certain 'ticks' are found to live as ectoparasites over the body of Lynchia.

27. Note on the occurrence of ovaries in the worker of the ant *Myrmicaria brunnea* Saunders.—*By* DURGADAS MUKERJEE.

It is held that the functioning power of the reproductive organ in the worker of ants, is determined by the condition of ovaries. The occurrence of ovaries in the worker of a few common ants is investigated and it is found that in the worker of *Myrmicaria brunnea* Saunders, ovaries consist of a single pair of narrow elongated ovarioles and a pair of oviducts, the receptaculum seminis being absent. No mature eggs were seen. The majority of workers, however, showed no trace of ovaries. In a few specimens of Simarufonigra, *Dicamma vagans* Smith, ovaries were also found absent.

28. The process of copulation in the earthworm *Eutyphoeus waltoni.*—*By* K. N. BAHL.

Grove has recently described the copulatory process in *Lumbricus* (Q.J.M.S. Vol. 69, 1925). He points out that the clitellum plays an important part in forming a receptacle with the body of the other worm where the sperms accumulate and from where they pass into the spermathecal openings. A *seminal groove* leads from the apertures of the vasa deferentia to this "receptacle" while each worm is enclosed in a slime tube composed of mucus secreted from the epidermis.

In *Eutyphoeus* the process is extremely simple. The clitellum takes practically no part in copulation nor is there any seminal groove or slime-tube formed. The two worms come to lie in such a way that the openings of the vasa deferentia of one lie opposite the openings of the spermathecae in the other and vice versa. Since there is only one pair of spermathecae in this species the transference of sperms from one worm to the other is direct. The penial setae which are very long are inserted into the spermathecal openings of the other worm and thus help in keeping them open.

29. On the Cirripede Genus *Lithotrya*, with special observations on *L. nicobarica* Reinhardt.—*By* R. B. SEYMOUR SEWELL.

The genus *Lithotrya* is a small group of pedunculate Cirripedes, and includes eight so-called species. Comparatively few examples of the genus have hitherto been obtained, possibly owing to an intrinsic rarity, but more probably to their peculiarity of habitat, for all the species of the genus have adopted the habit of forming burrows into which the animal can be completely retracted; with the exception of *Lithotrya cauta* Darwin, known from a single specimen obtained in N.S. Wales and lodged in a *Conia* shell, and *L. valentiana* (Gray) from the Red Sea and Zanzibar, which was lodged between the valves of an oyster, all the eastern species have been found in burrows in coral or coral-conglomerate, and the western of American species, *L. dorsalis* Sowerby, bores into limestone.

The author has been able to examine over 60 examples of *Lithotrya nicobarica* and a study of these throws grave doubts on the validity of several of these so-called species.

These cirripedes undoubtedly make their own burrows. The boring mechanism consists of a number of calcareous scales on the peduncle and of chitinous teeth on the lower margin of the valves. The larva must first select some small pit or crevice into which it can penetrate and settle down; it fixes itself by the peduncle and from then on, as growth occurs, both the length and diameter of the burrow are increased *pari passu* with the growth of the individual. As the calcareous plates and chitinous teeth get worn down they have to be replaced and this is achieved by a process of exuvation. This group of cirripedes either has retained this feature, so characteristic of the crustacea in general, of periodically casting their old shell and reforming a new one, or else, as seems more likely, they have re-acquired it. Periodically a new cuticle with calcareous plates is formed by the cutaneous epithelium underneath the old one, and when this is ready the old cuticle is cast off; but the successive layers of the valves remain for some time adherent to each other, so that as many as ten to fifteen may be found each supported on the one next formed. Eventually these superficial scales are also removed, probably by the burrowing or retractile movements of the peduncle, which rubs them against the edge of the cavity. At each exuviation the basal calcareous plate, by which the animal is anchored in its burrow, is also cast off and a new one is formed; we thus find in each burrow a series of these plates, commencing near the mouth of the burrow and getting larger as one proceeds further down, each new plate being formed over the top of that immediately above it. In conformity with the high degree of contractility, possessed by the animal, the upper portion of the peduncle is a hollow tube, lined with a thin layer of chitin, and into this the body can be retracted. This adaptation has led to the ovary becoming situated close to the base of the peduncle, between the two large retractor muscles that are attached to the body wall opposite the calcareous plate. As in the genus *Scalpellum*, the oviducts open at the base of the first cirrus and the eggs are poured out into the mantle cavity where they form a circular plate-like mass on either side of the animal. The breeding season would appear to be in the spring, for out of ten examples collected in March, which I examined and dissected, three contained these egg masses.

Of the eight species hitherto recorded, *Lithotrya nicobarica* Reinhardt, *L. truncata* Q and G., *L. pacifica* Borrodaile, and *L. conica* Hoek all come from the Malay region; *L. pacifica* and *L. rhodiopus* (Gray) from the atoll of Funafuti; *L. cauta* Darwin from N.S. Wales, and *L. valentiana* (Gray) from Zanzibar and the Red Sea; *Lithotrya dorsalis* Sowerby is known from Barbadoes, Venezuela and Honduras, but two varieties of this species, var. *maldivensis* and var. *rugata*, have been described from the Maldive Archipelago. The chief area of distribution of the genus lies clearly in and around the Malay Archipelago and the Western region of the Pacific Ocean, and the genus is essentially a tropical one.

Most of these so-called species, however, have been founded on small variations in the valves and the scales of the peduncle and from a large series of the present species it is possible to match all the various types. In a few species certain anatomical details have been described and have been cited as additional proof of specific difference, but here again most, if not all, of these differences can be shown in a large series of a single species to be due to age changes. The author is inclined to believe that the genus comprises, at the most, two species only.

30. *Isospora* (n. sp.) and *Balantidium* (n. sp.) in cattle—*By* HUGH COOPER *and* AMAR NATH GULATI.

This paper records for what is believed to be the first time the occurrence of *Isospora* and *Balantidium* in cattle.

During a tour in the province of Assam oocysts of the genus *Isospora* were discovered in five out of 181 samples of faeces collected from cattle. The five samples were preserved in formalin with a view to subjecting them to a detailed examination at the laboratory, but a period of about eight months having elapsed before the examination was started, the oocysts were found to have undergone an amount of disintegration which rendered them unrecognisable.

In the course of the examination, however, one of the samples of faeces was found to contain infusoria of the genus *Balantidium*, and on careful examination they appeared to differ in certain respects from any species yet described. A description of the parasite is given and the name *Balantidium bovis* is proposed for it.

31. On the occurrence of a lung fluke in a wild cat in Kumaon Hills.—*By* AMAR NATH GULATI.

Lung flukes other than those recorded from domesticated animals and man would appear to be of rare occurrence. Ward and Hirsch (1915) writing about the genus *Paragonimus* observe, that *P. rudis* (Diesing, 1850) from the lung of a Brazelian otter; *P. Compactus* (Cobbold, 1859) from the lung of the Indian ichneumon, have never been reported since they were originally described. This paper records the occurrence of *Paragonimus* in the lungs of a wild cat in the Kumaon Hills, and the systematic position of this parasite is also discussed at some length.

32. The reopening of the Invertebrate Gallery of the Indian Museum.—*By* R. B. SEYMOUR SEWELL.

The Invertebrate Gallery of the Indian Museum was reopened to the public after 12 years by His Excellency the Viceroy on December 22,

1925. The Gallery was originally designed and arranged by Dr. Anderson, the first Curator of the Indian Museum and Mr. J. Wood-Mason in the late Seventies. It was to some extent remodelled, especially as regards the Crustacea Exhibit by Col. Alcock, but in 1913 was closed for the purpose of a complete rearrangement. The outbreak of war in 1914, and subsequent lack of funds prevented the completion of the work till the end of 1925.

The species exhibited number over 5,000 and many of them are the fruits of the Biological Work of the R.I.M.S. "Investigator."

The arrangement and display of the specimens have been designed to assist the *bona-fide* student of Zoology, and the Gallery, as it now stands, may be claimed as the finest exhibit of Invertebrate Zoology in India and one of the finest in the world.

33. On some interesting features of the Fauna of the Western Ghats.—*By* SUNDER LAL HORA.

With a view to draw the attention of advanced students of Zoology of the Bombay University the author has described the habits of certain interesting molluscs found in the Western Ghats and has also referred to the peculiar freshwater medusa (*Limnocnida indica* Annandale) whose hydroid stage is not yet known. The two chief peculiarities about the fauna of the Ghats, are firstly the presence of representatives of a Marine fauna and secondly the adaptations exhibited by certain animals to the periodically extremely wet and dry weather conditions that prevail in this area at different times of the year. The author has summarised recent information available for the species discussed in the paper (viz. *Succinea arboricola, Cremnochonchus syhadrensis, Neritina perottetiana Lithotis rupecola, Lithotis tumida* and *Limnocnida indica*) and has indicated the lines along which further research can be conducted.

34. On the adults of Zoanthella and Zoanthina.—*By* K. R. MENON.

Two species of Zoanthella have been reared by the author into Sphenopus Marsupialis and a species of Gemmira respectively, and a species of Zoanthina has been reared into a species of Zoanthus. A second species of Zoanthina has also been reared by him into the parent form which he provisionally identifies as Isaurus.

35. Colony-formation in the Madriporarian genus *Symphyllia.*—*By* G. MATTHAI.

In the course of a paper read before the Section of Zoology of the Indian Science Congress in January, 1925, the author pointed out that Colony-formation in the Atlantic genus of Coral, *Isophyllia,* is by circumoral intra-tentacular budding, new stomodæa, and hence buds, being formed in concentric rings around the stomodæum of the mother-polyp. The latter is related to each stomodaeum of the primary ring by means of two interstomodæal couples of mesenteries, whilst each stomodæum of a ring is similarly related to two adjacent stomodæa of the succeeding ring. Subsequently, the author investigated, by means of transverse sections, the mode of Colony-formation in the Indo-Pacific genus *Symphyllia,* and the results are embodied in the present paper.

Budding in *Symphyllia,* differs from all other intra-tentacular modes that the author investigated inasmuch as adjacent stomodæa are directly connected by means of mesenterial strands, whilst interstomodæal couples may or may not be present. In other words, there is direct linkage of stomodæa in *Symphyllia,* whilst linkage of stomodæa is indirect in other genera.

Details are also given of intra-tentacular budding and dichotomous branching in *Symphyllia.*

36. Positive Phototropism in insects and its significance in pest control.—*By* M. AFZAL HUSAIN.

A number of the insects attracted towards light are serious pests of crops. Experiments to make use of this behaviour for pest control have been tried against *Nephotettix bipunctatus* and *N. apicalis*, as also against moths of sugar-cane borers, with some success. In case of *Amsacta* spp. this method of control has given excellent results. In the Punjab from an area of about 800 acres over 111,000 moths were collected in about a fortnight. Positive phototropism of these insects is so strong that both males and females fly towards light even before their sex instincts have been satisfied.

A number of factors influence phototropic response of insects such as previous exposures to light, temperature, humidity, intensity and colour of light, and power of flight possessed by an insect and great deal of work is necessary to enable one to use light traps effectively against all pests which manifest positive phototropism.

37. Some notes on a probable new species of Sessile Cirripedes from Karachi.—*By* VIDYA SAGAR.

This species comes under Section 'A' of the six sections into which Darwin has subdivided the genus Balanus; the distinguishing characteristic being permeation of radii by pores.

Of the eight species contained in this section, this species resembles *B. tintinnalulum* and *B. tulipiformis* in one or other respect and yet differ so markedly from both of them as to require a separate name for itself.

The distinguishing characteristics are as follows:—

The tints vary in transverse striæ in the first two species but in this one they vary longitudinally on the radii. The alæ, unlike *B. tulipiformis* cannot be seen externally.

The Scutum is rough, growth ridges very prominent and surface devoid of longitudinal striations and naked. Upper part not reflexed and basi-occludent angle of 60°, differentiating it from both of them in these respects.

The tergal margin is not inflected rectangularly as it is in *B. tulipiformis,* but is merely bowed inwards resembling in this respect, *B. tintinnabulum.* Also articular ridge ends in a free point, and is not confluent with the adductor ridge as is the case in *B. tintinnabulum.*

Unlike the two species mentioned above there is a closed canal on the tergum and the spur is placed at about more than its own width from the scutal angle. The opposite basal margin is wavy and the crests for the depressor muscle are not very prominent. Beak is not so prominent as in *B. tulipiformis;* nor like *B. tintinnabulum* is it so much reduced.

The summits of the radii and alæ are parallel; the tubes in the parieties are not crossed by septæ and the basis is cup shaped. These are again characters unlike those of the species referred to above.

In the mouth parts the Labrum has no teeth. In the maxillæ there is no notch under the two upper spines and the two spines in the lower pair are smaller than the upper pair. There is no intermediate tuft in III and IV cirri. These characters again are unlike to those of the two abovementioned species.

The only reasonable conclusion from this is that the species under consideration is a new one, not resembling any of those described by Darwin.

38. Spermatogenesis in common Indian Frog *Rana tigrina* —*By* Chandra Bal *and* Mahabir Prasad Misra.

The following has been recorded as a result of observations during the whole period from the time of spawning till the spermatozoa are again formed. After spawning crypts are found lined by one or often more than one layer of growing cells, each with one or more nuclei. In addition, some cells irregular in shape with deeply stained nuclei are noticed amongst spermatozoa lying free in the cavities of crypts. These correspond to Blastophoral cells of Blomfield. M. Duval describes these cells as forming "Male ovules." destined to produce the crop of spermatozoa for the next year and further says that it is possible to find a distinct gradation between these cells and the male ovules. We differ in this respect from M. Duval and agree with Blomfield in his interpretation of these cells. Later during winter season crypts are completely filled with sperm morulæ which lie pressed against each other. In the nucleus at this stage is seen a clear dark granule—nucleolus—lying usually to one side of it. Mitochondria are present as small granules collected together on one side of the nucleus outside it.

An account of formation and structure of spermatocytes and spermatids and reduction division is given. During spermataleosis spermatids elongate centripetally to give rise to spermatozoa Behaviour of Golgi apparatus is also studied to some extent.

Section of Botany.

President.—E. BLATTER, S.J., Ph.D., F.L.S.

Presidential Address.

FACTS AND HYPOTHESES IN THE PROBLEM OF EVOLUTION.

Botany is an empirical science, the plant its object. What we see and observe in the plant forms the contents of botany; but we are not thinking of our observations as raw-material, but as facts to be connected by the process of thinking and cleared up by scientific interpretation. This leads up from the raw-material to the crystallization of a small number of well-founded sentences by which we give expression to facts or present the efficacy of the laws of nature. A heap of types is not a book; in the same way, the mere accumulation of facts is not science. The economy of our thinking forces us to abstract general ideas from the variety of objects and, again, to combine those ideas into general statements of narrower or wider significance, and into laws which may be specific or of a more general nature. This is the way leading to the knowledge of the plant.

How far this ideal is removed from reality is known to everybody who has worked seriously in any branch of botany. The difficulties which stand in the way of the realisation of that ideal are many. Some come from the object itself, the plant. In many cases where we are not in a position to formulate laws, we have to be satisfied with mere rules which allow of a wider or more restricted application.

To a great extent the human weakness of the botanist has to be blamed who is ever ready, when experience fails, to fill in the gaps in his knowledge with speculation and who, in his desire for dogmatic finish, is only too often tempted to mix up mere problems with laws based on experimental facts. In order to justify such mistakes he applies the word theory to something that does not even deserve to be called a hypothesis.

A further aberration is caused by the fact that botanists are frequently guided in their judgment by tradition and school-opinion, whilst elimination of errors and search for truth should be the only guiding star. There is no dogma in science to which we should blindly submit.

But we have seen worse things in the botanical world, we have come across fashions. We admit, it is quite justified to strike out in a new direction of investigation after the prevailing interest in botanical research has followed a certain line for some time; but we cannot see how it works towards progress if the disciples of the new or so-called 'modern' school look down with conceit on the representatives of the old school or, as it is called, the 'antiquated' school. and vice versa. There are e.g. investigations in systematic botany which have been performed with the greatest possible mental acumen and, on the other hand, we meet physiological research whose intellectual value does not rise above a very moderate level. Both, however. help in the interpretation of nature.

But enough of these general considerations. I have put them before you in order that I may find it easier to make myself understood when I am going to speak of the 'Facts and hypotheses in the problem of evolution.'

We are botanists. We know the flora of the present day fairly well, we know its distribution, we know its aspects in various countries, we know a good deal about the migration of its members, we have classified the plants according to artificial systems and we have also tried to classify them according to natural systems. But we want to know more: we want to find out how the present-day vegetation came into existence, whether it is the product of evolution or not.

Whatever may be the answer to this last question, I am not going to discuss the origin of the first plant or plants on this globe. Observation and experimental science cannot give us a direct satisfactory solution of this question; but biologists have established the axiom: 'Omnis cellula e cellula,' and we are on firm ground when we conclude that the first cells cannot have evolved from matter, but that they must have been created. I take, therefore the first plants as given, not determining whether there were few or many, and whether they belonged to one species or to many. And now I put the question again: Is the present-day flora a product of those first plants?

You all will say: 'Yes,' and I say 'yes' with you But now let us be absolutely honest, let us forget for a moment that those were great naturalists who put the idea of evolution into the world, let us forget that the whole scientific world *believes* in evolution, (I say on purpose 'believes'), let us forget that evolution has become so to say a universal law invading every domain of human knowledge, let us also forget that almost every fact in the organic world is being studied with a view to ascertain its significance in the great scheme of evolution: and now let us approach the problem without prejudice, without inclination towards the opinion of this or that school of thought.

1. *Fact and speculation.*—There is no branch of botany in which the differences are more prominent between experience and speculation, between fact and hypothesis, between knowledge and belief, between scientific and philosophical treatment of the problems, than they are in the field of the theory of evolution.

At the same time there is no other field in which, through the mixing up of actual experience with philosophical speculation, there has arisen a greater pseudo-scientific confusion. You must not think that I want to condemn philosophical speculation; it is justified side by side with experience; but it becomes unscientific as soon as we cease to know exactly where experience stops and where speculation begins, when we ignore how much of the theory of evolution is scientific fact and how much is mere philosophical conjecture. It is just here that we should carefully distinguish between the results of observation and the products of our imagination.

2. *Systematic and historical treatment.*—The chemist and physicist as well as the botanist are dealing with facts. In physics and chemistry facts that have been ascertained are classified and their mutual relations investigated; laws are recognized only in cases where they have been proved to be constant. In chemistry the elements are accepted as a given variety, so are the forms of energy in physics; we do not inquire into their origin.

But in botany it is the historical consideration that is more prevalent. We consider the plant as the result of an historical process, and by this method botany resembles geology. We want to know e.g. where the species come from, and we try to find an answer in the theory of evolution.

3. *Two facts and one hypothesis.*—The answer which may vary a good deal as regards detail is based on two facts to which evolutionists have added an hypothesis.

The first fact is the uninterrupted continuity of birth in any series of descendants. We can accept this fact without hesitation, as we start from the supposition that the laws of organic formation were the same in former periods as they are at present. It we deny this principle we must also deny to cosmogony, astronomy and geology the right of investigating into the past, because the laws of nature might have changed in course of time.—The second fact is the positive knowledge that in former geological periods our globe was covered with a vegetation which was different from what we see at present.

These are the two facts: continuity of birth and a different vegetation in former periods. Now I ask you, ladies and gentlemen, what can we conclude from these two facts? Nothing at all. Are we justified in drawing the conclusion that our present species are not the product of evolution? Certainly not. Can we conclude that evolution *has* taken place? By no means. The mere fact that the records of palaeo-botany show us plants which do not exist in our days does not prove anything. That fact would prove evolution if we could show that those fossilised plants were the ancestors of our modern plants. But this is an almost impossible task. Anybody who has followed up the attempt of systematic botanists during the last 40 years will admit the enormous difficulties that stand in the way of working out a genealogical tree or trees. I think there was no botanist after BENTHAM and Hooker who had a better grasp of systematic principles and who tried harder to frame a natural system on the basis of evolution than Engler. And it was he who confessed in the last edition of his Syllabus der Pflanzenfamilien (1924): "Though I expect results from phylogenetic methods in the study of single families, especially with the aid of plant geography, I cannot help being sceptical with regard to many attempts to derive families from one another, either from living or extinct ones."

But I must not cite authorities. As I said before, our investigation is an independent one.

What then shall we do if the two facts mentioned above do not lead to any conclusion? We could drop the question altogether; but this is not satisfactory to the inquisitive mind of a scientist. So the question remains: Are the present-day plants a product of evolution? As only those two facts are at our disposal and as they revealed themselves to be barren, there is only one solution possible, *viz.* to call to our aid a hypothesis. We may formulate it in this way: Let us suppose a phylogenetic development of the plants which, on the whole, progresses from single to more compound forms and which is analogous to ontogeny that begins with a fertilized cell and developes a highly organized body.

This is the hypothesis which is the foundation of every investigation connected with evolution. And it is *only* a hypothesis and nothing more, and the fact that it is called theory of evolution does not change matters in the least. It is a hypothesis and will remain a hypothesis till phylogenetic evolution has been proved to be a fact.

Astronomy and biology have telescopes and microscopes to reveal a variety of things coexisting in space which to the unarmed eye remain hidden, but we do not know of any instrument or method by which we could penetrate or illumine the darkness of the past. We can, however, link up a modest number of facts by philosophical speculations and in this way the treatment of the problem develops into a discussion of possibilities, but never beyond, unless what our hypothesis contains is no more hypothetical but real. As long as we use our hypothesis as a heuristic working hypothesis and do not enunciate it as a scientific dogma, it may bear ample fruit in the tracing of connections between organisms. Just because it has done so up to now, it is of great value even to the purely empirical science.

But it will do harm to human knowledge as soon as we see in it more than a mere hypothesis. We have only to think of the fanciful and wild imagination betrayed by some fanatical defenders of the theory of evolution.

4. *Foundation of Speculation.*—The objective value of every speculation in natural philosophy grows with the number of clearly ascertained facts on which it is based. Considered from this point of view the theory of evolution is not well off.

We gather our facts and observations from two sources: from the fossilised plant world and from the changes which can be observed in the living vegetation. There is no other source if we want facts. All the rest is speculation, made up of conclusions from more or less important indications, of the discussion of possibilities and probabilities, in short, of hypotheses which can neither be proved nor refuted.

The amount of material accumulated from both fields (fossil and living vegetation) is great, and still the theory of evolution receives little light from it. The facts are rarely quite univocal, and it is for this reason that there are scarcely two botanists whose convictions as regards the theory of evolution are the same, whilst other speculative domains of natural science, e.g. stereochemistry enjoy the approval and consent of a large number of scientists. This also explains the strange phenomenon that from time to time a radical agnosticism in questions relating to evolution is gaining the upper hand. Agnosticism, of course, is the most convenient attitude towards such problems: it saves us the trouble of thinking!

5. *Palaeobotany: (a) Cryptogams.*—Let us first consider the results of palaeontology. The history of the past teaches us without doubt that in former geological periods the vegetation was different from ours. No plants have been preserved in the Pre-Cambrian and Cambrian rocks. The oldest plants, according to our present knowledge, have been found in the Silurian rocks—*viz.* ferns which resemble those of the present day. But I must not anticipate.

Of the Thallophytes (Algae, Fungi and Lichens) only those species could be preserved which, by the deposition of calcium carbonate and silica in their cell-walls, formed a skeleton able to be fossilised, whilst the soft species soon became a victim to putrefaction. We find, therefore, amongst fossil Algae only Diatoms and Chalk-Algae. The Diatoms go down right to the carboniferous age and they are scarcely distinguishable from the living ones. Of the Chalk-Algae we must separate two types: the simpler Siphoneae and the more complicated Corallinaceae. The Siphoneae occur already in the Silurian age and amongst them we come across forms which resemble the modern types. Even a living genus (Bornetella) seems to occur in the Silurian rocks. Corallinaceae, on the other hand, are known only from the Jurassic, Cretaceous and Tertiary deposits.

At the present day every organism which is not preserved by special circumstances, succumbs to putrefaction brought about by Bacteria. As we have good reason to assume that the soft parts of plants putrefied already in the oldest strata, we are allowed to draw the conclusion that Bacteria existed in those periods. But we have also direct indications of Bacteria having destroyed wood during the Carboniferous age. Well preserved fossils of Fungi have not been observed, but the Tertiary period has preserved a number of Lichens which agree with existing genera. As the bark of our trees is usually inhabited by Lichens, it is a striking fact that no Lichens have been discovered on the bark of the Carboniferous strata. It is not unlikely that Lichens did not exist in that period.

Mosses in greater variety date back to the Tertiary period and they are mostly forms which resemble the Mosses of to-day. Some incomplete fragments, however, seem to have come down to us in the Cretaceous and Jurassic rocks.

Ferns have already been found in Silurian times, i.e. in the oldest formation which contains plant fossils at all. It is interesting to note that those Ferns had reached the same degree of organization as ours. From the Silurian rocks upwards we meet Ferns everywhere, but they reach the height of development in the Carboniferous period, and it is here where we come across types which are more perfect anatomically than the present ones.

The Equisetaceae show the optimum of development in the Carboniferous strata. Similarly, the Lycopdiales attained the maximum of form and organisation during the same period. Lepidodendraceae and Sigillariaceae become extinct during the Permian and Triassic ages, which also saw the end of the tree-like Calamites.

If we compare all the data of palaeontology regarding cryptogamic plants we have to admit that there are no forms which might be considered as connecting links between Algae and Mosses, or between Mosses, and Ferns. On the other hand we notice that all the classes of Pteridophytes reached their maximum development already during the Carboniferous period.

(*b*) *Phanerogams.*—We come to the Gymnosperms with the families Coniferae, Cycadaceae and Ginkgoaceae.

The oldest Gymnospermous types are the Cordaites. Traces have been discovered in Devonian rocks; after having attained their richest development during the Carboniferous age they are no more found in Permian strata. No other Gymnosperms can, with certainty, be traced in Carboniferous rocks. The first reliable fragments of Cycadaceae are Permian.

In the Triassic and Jurassic strata we find extinct genera of Cycadaceae, Ginkgoaceae and Coniferae. The maximum of their development coincides with the Jurassic period, which has seen the first still existing Coniferous genus Araucaria. In the Cretaceous rocks numerous genera made their appearance which have continued up to the present day. In the Tertiary strata we find only genera which still exist, and in many cases even species.

No traces of Angiosperms have been discovered in the lower Cretaceous rocks. In the upper strata, however, we meet on a sudden numerous Monocotyledons as well as Dicotyledons which show considerable resemblance to their modern relations. The Tertiary period discloses representatives of still existing families, genera, and species.

What are the results of this short evidence of palaeobotany? No close relationship between the oldest Gymnosperms and Angiosperms can be established. Both phyla of Phanerogams are as sharply separated in their fossil types as they are in the living ones. The Angiosperms are very young; we know them only from Cretaceous rocks. The Gymnosperms may be as old as any plant-remains; if we do not find them in the Silurian strata it may be explained by the fact that very few land-plants have come down to us from that formation. Later on the Gymnosperms as well as the Angiosperms approach the living types more and more, especially in the Tertiary period. In spite of this it is impossible to trace transition series between Tertiary and living species in a satisfactory way. Wherever such transitions have been constructed they are uncertain and allow of no univocal interpretation.

6. *Variation and Experimental facts.*—We have dealt with the palaeobotanical record. It remains to be seen what observation and experiment in the living plant can tell us regarding the theory of evolution.

When we speak of variation we generally mean three groups of phenomena: (*a*) Individual differences; (*b*) single variations; (*c*) forms produced by crossing and Mendelian segregation. The question before us is this: What influence have these variations on the formation of species?

7. *Individual differences.*—We call individual differences all fluctuating inequalities of an individual and of its organs—e.g. the hairiness of the leaves of a plant, the percentage of starch contained in a grain of wheat, and even more important features of a morphological and physiological nature. These differences, whether quantitative, meristic or individually quantitative, oscillate around a certain mean. We are told that useful individual differences can be increased indefinitely by selection and may finally become independent of selection.

But how do we know that everything that is ascribed to selection has come into existence *through* selection? We know many races of cultivated plants, but do we know their origin? Besides, many cultivated forms owe their origin not to the mere strengthening of individual characters, but to crossing and segregation of characters. If we consider only well attested facts we must arrive at the conclusion that selection does not bring about anything *new* and that the maximum amount of quantitative modification is brought about in a few generations (mostly in three to five) and that only continued selection can maintain this amount. Stopping selection means inducing regression. New species, therefore, cannot arise through selection.

But does not environment influence plants and mould them in many ways? Quite so, but experiments show that changes of characteristics and niceties of adaptation go to and fro without transgressing definite ranges of variation. And how are we going to explain the discontinuity of species in the presence of a continuous environment, whether it has acted directly in the Lamarckian sense, or as a selective agent as explained by Darwin? We would have to call for accidental destruction and isolation of intermediate forms, in other words: a second hypothesis would have to give strength to the first.

8. *Single Variations.*—What is the significance of single variations for the theory of evolution? When from among a large number of offspring some particular individual differs from the rest in one or more characteristics and transmits them to posterity, we speak of single variations and call the whole process mutation. If de Vries's new forms are really new ones, and if future experience shows that they do not owe their origin to some unexpected original cross, then, and then only can we say that single variations are of importance for the solution of the evolution problem, because they are discontinuous and constant and would, therefore, be capable of explaining the gaps between extinct and existing species. But till the possibility of an original cross is completely excluded, de Vries's theory can only be used as a Hypothesis in the explanation of evolution. Even when the time comes, when no doubt attaches to de Vries's experiments, there still remains the remarkable fact that the fertility of mutants decreases considerably, and this fact becomes the more pronounced, the greater the deviation from the parent. In addition, the newly produced mutants are comparatively weak. These two facts require careful consideration when we try to determine the value of single variations for the evolution of species. Finally we must not overlook the fact that those mutants do not exhibit any progressive development. The new forms have not shown the slightest progress in organization, not even indications of any kind of advancement in that direction.

9. *Crosses and Mendelian Segregation.*—We have now to pay a few moments' attention to crosses and Mendelian segregation. As regards cross-breeding in nature we can hardly consider it as a factor in the progressive evolution of species. We know by experience that forms of different degrees of organization do not cross, and even if they did, all deviations would soon be equalized according to the laws of chance and probability.

Apparently greater importance must be attached to the Mendelian segregations. You all know Mendel's rule. A simple analysis reveals three parts: (*a*) By fertilization the characters of the parents are united, but they do not lose their purity and independence; (*b*) In the offspring the characters of both parents may again be separated from each other; (*c*) The character of one of the parents may completely conceal that of the other. We know, however, from subsequent investigations that the latter part is not necessarily connected with the rest. I must add that Mendel's rule also holds good for the offspring of hybrids, in which several constant characters are combined. This is a splendid confirmation of the modern theory of the cell.

What is the bearing of Mendel's rule on the theory of evolution? We cannot deny that it gives support to the idea that gaps in nature can originate through such segregation. But can the idea be applied to the formation of species? We cannot answer this question at present. One thing, however, is certain, segregation does not bring about any progress in organization or any progressive specific development.

10. *What follows for the theory of evolution?*—Now that we have given a short survey of the facts of variation we naturally wish to draw conclusions. The central idea of modern evolution theories is progressive specific development. I appreciate the enormous amount of work that has been done in the way of elucidating the problems of variation, and we have to be grateful to the botanists and biologists who have put at our disposal an immense number of experimental facts, and we cannot help admiring the acumen and devotion that have been employed in the co-ordination of new observations and discoveries towards the construction and consolidation of the theory of evolution. At the same time I must confess that all the observations gathered from the world of organisms as it now exists does not give any confirmation to the theory which wants to explain the evolution of new species. What we have before us are hundreds of hypotheses; a few are leading ones, some are subordinate, and others do not even deserve the name of hypothesis. I am not exaggerating when I say that in most of them the speculative element preponderates over facts, and it would not be difficult to show that many are the product of mere imagination. If the fact-element were more prominent in all the treatises that have been written on evolution by defenders of evolution, botanical literature would not offer so many different views and opinions on the same subject, such a variety of contradictory statements, so many empty terms and meaningless phrases which can only have been coined in dream-land, but especially we would not come across so many personal attacks amongst colleagues which only betray the absence of facts.

11. *Conclusion.*—We have, therefore, not yet a satisfactory

reply to the question: How did the present flora come into existence? The greatest difficulty is to explain the origin and constancy of new characters and the teleology of the process. The question as to the transmission of acquired characters is not by any means decided. The doctrine of propagation tells us that only such characters can be transmitted as are contained in the germ-cells or which have been either directly or indirectly transmitted to them Hence it is clear that all peculiarities acquired by the cells of the body through the influence of environment, or by use or disuse, or any other agent, can only be inherited if they are handed over, so to say, to the germ-cells. But it is useless to discuss the question before we have sufficient experimental evidence that acquired characters are at all inherited.

Darwin's 'natural selection' is only a negative factor when we want to use it for the explanation of the origin of new characters. It is quite true that the plasticity of organisms has been proved by a number of experiments to be considerable. In a constant environment and by single variations changes may be effected which a systematist would classify as specific or even generic, if it were not clear from other sources that they are not such; but at present we are unable to ascertain how far that influence may extend. Lamarck's 'Inheritance of acquired characters' is not yet exactly proved, nor is it evident that really new forms can arise by mutation.

All this does not sound very encouraging. The theory of evolution is no more than a hypothesis, and it is highly unscientific to proclaim evolution as a well-established theory or as a fact, whether this be done in scientific treatises or in popular books. Science does not gain by exaggeration. It will make progress only by drawing legitimate conclusions from facts. We shall serve science much more efficiently by confessing ignorance where there is ignorance, than by constructing a system made up almost entirely by hypotheses, views, opinions, indications, probabilities, and possibilities and only here and there supported by a meagre fact whose interpretation is only too often ambiguous

Does this mean that we should give up the theory of evolution? Far from it! I suppose I am right in assuming that you *believe* in evolution! and so do I. I said on purpose 'you *believe* in evolution.' There cannot be a question of conviction for a scientist where not every link leading up to his theory is an established fact or a legitimate conclusion from facts. For us the mere idea of evolution has a peculiar charm. We are surrounded by a variety of organisms which are teaming with problems, whether we find them in geological strata, or on the surface of our globe, or in the air, or in the water. We want to find an answer to all the questions which nature itself puts to us. There is especially one mystery the human mind wants to solve, viz. the origin of our species. It is a mystery of absorbing interest, whose solution will throw light into the remotest periods. We are still groping in the dark and sometimes it seems as if the sun would never rise on our mental horizon, as if the past would for ever remain a sealed book to the inquiries of our mind. At present we try to find the solution of that mystery in the theory of evolution. There are many facts and many indications that point in that direction; we seem to feel that we are on the right path, though we are not as yet able to furnish convincing arguments to establish the truth of evolution. It is a gigantic problem and we may not see its solution.

It is over 100 years since Lamarck offered the world the first theory of evolution. His period ended with an almost complete victory for the theory of constancy (1830). Then came Darwin and gave us his 'Origin of Species' (1859). His theory entered into every department of the biological sciences and to a great extent transformed them. After Darwin followed a period of critical reaction and we belong to that period. We are not able to say what changes may befall the problem of evolution during the 20th century. One new discovery may bring a solution we never dreamt of, or it may revolutionize our views and opinions, or it may even destroy our hopes and aspirations to see the theory of evolution confirmed and established. Whatever may happen and whatever the solution may be, we shall never regret having used the theory of evolution as a working hypothesis. It has opened out vast fields for investigation, it has called into life new branches of the biological science, it has given renewed interest to many departments of botany which were threatened to become dry archives of names and descriptions without an intellectual foundation, it has multiplied and perfected the methods of scientific investigation, and above all, it has given an importance even to the smallest detail of scientific knowledge, because there is nothing that has not been requisitioned to serve as a building stone in the construction of the theory of evolution.

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Abstracts of Papers.

1. Note on the colour of the flowers of *Potentilla argyrophylla*, Wall., and *P. atrosanguinea*, Lodd.—*By* SHIV RAM KASHYAP.

The two species are said to differ in flower colour only—*P. argyrophylla* having yellow flowers and *P. atrosanguinea* red flowers. Hooker in 'Flora of British India' makes the latter a variety of the species which he calls by the former name. Collett describes the two as distinct species but says that they differ in flower colour only.

The writer saw many specimens of these plants this year growing below the Rotang Pass, at an altitude of 10,000 to 13,000 feet. The flowers were not only red and yellow in colour but all grades between deep scarlet and bright yellow were noticed, different grades sometimes occurring on the same plant. There were thus light yellow, orange, yellowish red, light red, etc.

The distinction between the two species or varieties, therefore, breaks down.

2. On the structure and function of the stinging hairs of *Tragia involucrata* Linn.—*By* S. C. SINHA.

Characteristic features of the stinging-hairs found in *Tragia involucrata* Linn. :—

(1) The elongated central cell which is the stinging cell proper is sub-epidermal in origin.

(2) A few peripheral cells which are epidermal in origin ensheath the central cell to about $\frac{3}{4}$ ths of its length.

(3) The portion of the central cell which projects beyond the limits of the peripheral cells is shaped like a slender cone and ends in a sharp point.

(4) The conical end of the central cell contains a sphærraphide of calcium oxalate, one of the projecting ends of which is strongly developed and sharply pointed and extends to the extreme tip of the stinging-cell. The whole sphærraphide presents the appearance of a bayonet and may be termed a "bayonet crystal."

(5) The needle-shaped process of the crystal penetrates the skin ; the cell-wall slips back over the needle into folds.

(6) The needle prepares the way for the injection of the poison into the skin of the aggressor.

(7) The poison contains a large amount of protein material held in solution in the cell-sap, and resembles in many respects an enzyme.

3. Heter-archic Roots in *Enhydra fluctuans* Lour.—*By* G. P. MAJUMDAR.

Enhydra fluctuans Lour. gives out from the same node roots of two different kinds which show heterarchy in the arrangement of their vascular tissues. The thinner roots uniformly show tri- arch arrangment, and the thicker ones, though apparently indistinguishable, show both tetra-and pentarch types of arrangement. The origin of all the three types is distinct and separate, and not that one is derived from the other in its onward ontogenetic development.

4. Tendrils of *Cucurbita*—its morphological nature.—*By* G. P. MAJUMDAR.

Tendrils of *Cucurbita* are modified extra-axillary buds. The arms are modified leaves. In the case of single unbranched tendrils, the lower portion is the shoot-stalk, and the arm (upper portion) is a leaf modified. In branched compound tendrils the lower unbranched portion is the stem-axis (internode); at each node three tendrils are given out of which one is a modified leaf, and the other two are modified buds, each consisting of a shoot-axis and a leaf modified. In the centre another bud is developed which in normal shoots develops into a flower or a branch. This in turn produces three tendrils and a central bud and so on. Finally this central bud ends in a single unbranched tendril.

5. Negative geotropism in *Impatiens balsamina* Linn.—*By* G. P. MAJUMDAR.

Negative geotropism in *Impatiens balsamina* Linn. is brought about by the difference in osmotic pressure on the two sides of the geotropically reactive cells in the swollen nodes. This difference is brought about by the change in the consistency of the cytoplasm, the heavier (concentrated) portion coming to rest on the physically lower walls due to gravity. Starch grains in the endodermis (statoliths) have no part to play in the bringing about of this curvature, rather their function appears to be nutritive.

6. A short study on the configuration and the formation of sexual organs in *Marchantia palmata* in relation to aeration.—*By* H. CHAUDHURI.

Plants grown on blotting paper inside petri dishes and kept near the window had the lobes elongated and pointed towards the source of light in about a fortnight's to three week's time.

When the petri dishes were sealed, the lobes grew erect, without pointing towards the source of light and the abundant rhizoids produced grew dia-geotropically. The effect of sealing was apparent from the third or fourth day.

Next a series of plants growing in soil on glass plates were put inside moist covered vessels and a similar set of plants were put inside similar set of vessels but which were aerated regularly. Only in the former cases the plants became vertically elongated. When in some the covers of the sealed vessels were removed after sometime, the later growth of the lobes pointed towards the source of light, and when again covered, the lobes grew vertically again.

In the covered vessels the time of reaction could be reduced by increasing the CO_2 contents; this was done by putting some germinating seeds inside the vessel.

Plants grown in this artificial condition failed to produce gemmae but bore sexual organs abundantly at the tips of the elongated lobes long before the control plants had produced any.

Further detailed studies are proceeding.

7. Seasonal influence on the water requirement and growth of Bajri (*Pennisetum typhoideum*).—*By* S. V. GODBOLE.

The paper deals with results obtained from fortnightly sowings of bajri in small plots during two years. (November, 1921 to December, 1923).

The total requirement of water during the four months of growth was greatest in summer and least during the rains.

The seasonal influence showed itself in quick vegetative growth and early flowering in the Kharif season, while in cold season the vegetative growth was at a minimum and the flowering delayed considerably. Further, as the rainy season approached, there was a decided tendency towards quicker growth and early flowering.

8. Luminous leaves and stalks from Bengal.—*By* S. R. Bose.

Prof. Buller of Manitoba—Winnipeg in his "Researches on Fungi" vol. III published in 1924 says at p. 426 that luminons leaves in addition to occurring in France, Germany, and Java, as reported by Tulasne and Molisch, also occur in England, Canada, and the United States, and that as time goes on. doubtless many other countries will be added to the list.

This year in July I got a collection of decaying leaves, small pieces of dead wood, living grass roots and stalks, living fern pelioles and living roots of *Averrhoa carambola* etc., giving out a distinct soft white light, from Barisal in Bengal. Four years ago 1 got a similar collection of luminous leaves, wood etc., from Bikrampur District in Bengal. They were collected from an unclean forest where fallen leaves had gathered for a number of years covering the forest-bed. In most cases I could find an uncoloured fungus hypha in their section. In some, luminosity was confined to certain spots, while thin flat surfaces in others were luminous all over.

Molisch ascribes the cause of luminosity to the fungus in decaying leaves, but he could not isolate the fungus, neither could he raise it in pure culture. The theory propounded by Molisch is that the fungus gives out a photogen which coming in contact with oxygen and water gives out light, by a process of slow chemical combustion without production of heat. But the photogen could not be extracted. When I crushed those specimens in a mortar in the dark room, luminosity failed altogether, showing that the photogen is bound up inseparably with the protoplasm of the living hyphae continuing to emit light so long as the fungus is in a living condition. The response of the light-giving substance was in every way similar to that of a living one *viz.*, in passing currents of pure oxygen the specimens glowed more intensely than before, while on passing currents of pure hydrogen, nitrogen, and carbon-dioxide gas there was temporary dimunition of light. When specimens were put in a vaccum-bath and the air pump was used, the light failed, but luminosity revived at once on letting in air. Specimens immersed in dilute solution of hydrogen-peroxide glowed more strongly than before. Luminosity failed permanently by dipping the specimens in strong alcohol or chloroform, thus showing that if the fungus is somehow killed there can no longer be production of photogen.

The present lot of specimens remained luminous for about five weeks, being kept in moist condition. Some of the specimens which were dried in blotting paper for more than four weeks lost their luminosity in the dried condition, but the luminosity revived partially when they were again put in contact with water This is because the fungus hyphae are able to remain alive in a desiccated condition for sometime.

A photographic plate could be developed by exposing the film side to the direct action of a luminous stalk for nearly 48 hours, keeping a control.

The mycelial culture of the fungus from the decomposed luminous leaf on sterilized moistbread medium in Erlenmeyer flask is proceeding.

9. Injection experiments on plants.—*By* S. R. Bose.

Injection of very dilute solution of Ferrous Sulphate ($FeSO_4$) (.25%) into the stem of completely yellow chlorotic *Mimosa* plants (*Mimosa* *pudica*) thoroughly changed them into their normal green forms in course of three to four days. The method adopted was that .25% solution of Ferrous Sulphate was injected into the stems of the *Mimosa* plants in their own habitat by means of a hypodermic needle, the basal end of which was connected by means of a rubber tube with a graduated glass tube fixed on a stand. The graduated glass tube was filled with ·25% solution of Ferrous Sulphate, few drops of machine oil were poured on the surface of the solution to prevent evaporation, the stand was placed on a stool at some height from the ground and the needle was kept on for a number of days, so that the solution might get in by means of continuous downward pressure. The quantity absorbed daily was noted. The rate of absorption varied, depending on various external conditions and individual requirements of plants.

Varying strengths of the solution, from .1% to .5%, were tried and it was found that very good results were obtained with .25% solution and .5% solution. With .1% $FeSO_4$ the result was unsatisfactory.

Two precautions had to be taken in such experiments to remedy the choking of the narrow bore of steel needles and to prevent the leaking out of the solution from the joints. The needle should be inserted right into the wood of the stem of the plant, taking care that air might not get in.

Corresponding strengths of the solution of $FeSO_4$ were poured on the soil bearing yellow *Mimosa* plants and they were watched for a number of days; the response was very feeble and very slow, a few leaflets turning green after a lapse of about a week. And it took more than a month to turn the whole plant green.

Subsequently when repeating the experiments, the iron salt was omitted altogether and a new set of yellow *Minosa* plants were injected with very fainty acidulated water (one drop of sulphuric acid in 100 cc. of water). In course of 5 to 6 days every one of these yellow plants turned green.

Next, injection of similar acid water was tried into the stem of some stout medium sized *Ixora coccinea* with yellow leaves. In course of 11 days the whole stalk with sub-branches turned green.

These results lead me to think that the yellowing of leaves is not due to the absence of iron within the plants, but that iron becomes precipitated in some form either in roots, stems, or leaf stalks, and that it fails to reach the leaves, that the effect of injection of acid water is to convert the immobile iron into its mobile form and to carry it up to the leaves along with the stream of ascending sap. This probably explains why of the *Mimosa* plants growing from the same soil and on the same spot, some were yellow while other neighbouring plants were quite green and normal.

These results are being followed up by chemical analysis of both healthy and diseased plants to find out the quantity of iron deposited in roots, stems, leaf-stalks, and leaves, part by part, in order to bring out whether yellow plants contain a larger quantity of iron in roots, stems, and leaf-stalks than in the actual blades of leaflets.

10. The relations between water content and photosynthesis in leaves.—*By* R. H. Dastur.

Some time back a view was put forward that the photosynthetic decay in leaves was very probably caused by an inadequate water supply. Since then the author has tried to obtain experimental evidence in its support. An apparatus has been devised to measure the rate of assimilation of one single leaf under constant and uniform conditions. The leaf experimented upon is not detached from the plant as has been done by previous investigators on photosynthesis. The leaf and the plant are both kept under same external conditions.

The rates of assimilation of leaves of different ages from various plants are measured by means of this apparatus and the water content of each leaf is then determined. It is found that low rate of assimilation is accompanied by a low water content while high rate of assimilation is found with high water content when working with different leaves of the same plant.

Though very close correlations have been established between the amount of water content and the rate of assimilation it is not still maintained that the photosynthetic activities of a leaf depend mainly on the water content.

11. Extraction and estimation of the green pigments from leaves of Indian plants.—*By* N. A. Buhariwala *and* R. H. Dastur.

For researches on photosynthesis chlorophyll is required in solid form. It is therefore undertaken to find a suitable plant for the purpose. For extraction Willstätter's method is adopted with certain minor changes. In order to make quantitative estimation of chlorophyll in leaves of different plants chlorophyll from one leaf from each plant is extracted and the concentration of the solution in ether is determined by comparing it with a standard solution in a spectroscope. This method of determining the quantity of chlorophyll from one single leaf is found very useful in finding out the amount of chlorophyll in leaves of different ages.

12. The influence of an aquatic medium on plants not necessarily aquatic.—*By* J. F. R. d'Almeida.

In this paper are recorded a few experiments and observations made on certain plants (*Jussiœa suffruticosa* Linn., *Malachra capitata* Linn., *Asteracantha longifolia* Nees., *Sesbania aculeata* Poir., *Sphenoclea Zeylanica* Gaertn., *Ageratum conyzoides* Linn.) which are frequently found by the water side. These plants exhibit marked differences when growing in water and out of water. Immersion usually causes a dilatation of the stem and adventitious root formation. The uses to which the structures thus produced are put seem to depend upon the requirements of the plant.

13. Some notes on the structure and life history of *Nymphœa pubescens* Willd.—*By* J. F. R. d'Almeida.

Nymphœa pubescens Willd. presents many features which have not so far been observed in Water lilies. The dry dormant stage which, for convenience sake, is called a "tuber" is not to be compared with tubers produced on some other Nymphæas. It is nothing but the rhizome of the previous season swollen up and laden with food-material. The plant sprouting from the tuber when the tank gets full of water again the next season shows a succession of leaf-forms observable in the seedling stages of this and other Nymphæas. Accommodation takes place in the length of the first internode of the plant developing from the tuber. The tuber is capable of germinating again and again if the plants which it produces become detached. Thus the tuber serves for perennation as well as for vegetative multiplication. The paper also includes an account of pollination and germination of the seed.

14. The biological significance of the pit on the lower involucral glume of the sessile spikelet in *Dicanthium panchganiense* C. McCann, sp. nov.—*By* C. McCann.

Morphological description of spikelet, glume, and pit. Relative position of anthers and pit. Viscid fluid in pit which shows different characteristics at different periods of the flowering season. Probable explanation of the presence of the pit.

15. Studies in the nutrition of the lac insect. Part II.—*By* M. SREENIVASAYA.

The fact that seedlings of *Acacia* and *Butea*, which have been previously grown in rich soils, continue afterwards to grow and maintain lac insects successfully, when fed with only simple distilled water, suggested the possibility of storage of nutrients. *Butea frondosa* in particular has a succulent, tuberous root, which is obviously its chief storage organ. Infected *Butea* and *Acacia* seedlings together with uninfected controls were grown in distilled water in order to examine the biochemical changes induced in the plant on insect attack and more particularly the translocation of carbohydrates and inorganic constituents from the storage organs to the region of attack.

Plants which are thus forced to exhaust themselves, approach the "physiological zero" and develop an avidity for the limiting nutrients. An attempt has been made to measure the intensity of this avidity by determining the rate of absorption of nutrients.

16. A note on the succession of species leading to grasslands on a trap hill.—*By* S. M. PHADNIS.

I. The climatic and edaphic conditions of the area under investigation are very briefly described.

II. The method of studying the succession was one of inference.

III. Definite stages in the succession from the pioneer rock lichens to stable grassland are described.

17. The Mangrove vegetation of the Indus delta.—*By* E. BLATTER.

Composition: *Avicennia officinalis* L., *Aegiceras majus* Gaertn., *Sonneratia acida* L. f., *Bruguiera conjugata* Merr., *Ceriops candolleana* Arn., *Ceriops roxburghiana* Arn., *Rhizophora mucronata* Lam., *Rhizophora conjugata* L.—Comparison with the Mangrove of other parts of Indo-Burma.—Local conditions under which it grows in the delta.—Characteristics of the Mangrove swamps.

18. Flora of the Indus delta. Results of a tour in October 1922.—*By* E. BLATTER.

Area examined. Physical aspects. Meteorological conditions.—Riverain forests, deciduous forests, savannah, grassland, desert, ruderata, hydrophytic and halophytic formations, cultivation.—Composition: 202 genera comprising 330 species, of which 48 genera with 54 species are introduced. Out of 70 indig. families there are 33 families with 1 genus only, and 26 with 1 species only. If all families are considered: 41 with 1 genus and 33 with 1 species.—Prominent families: *Gramineae* (44 species), *Leguminosae* (34), *Compositae* (18), *Euphorbiaceae* and *Convolvulaceae* (15), *Amarantaceae* and *Cyperaceae* (12), *Malvaceae* and *Solanaceae* (10), *Asclepiadaceae* and *Boraginaceae* (9), *Acanthaceae* *Capparidaceae* and *Tiliaceae* (8).—Comparison with the Desert Flora of W. Rajputana and Sind, and with the flora of the Ganges delta.

19. The grasses of the Indian Desert.—*By* E. BLATTER.

Area considered: Sind north of Indus delta, Indus delta, W. Rajputana, Cutch. Topography and meteorology of this region. Geographical relations with neighbouring countries. Composition: Genera 50, species 119.—Dominant genera: *Panicum* (14 species), *Eragrostis* (11), *Pennisetum* (8), *Andropogon, Chloris, Sporobolus* (7), *Aristida* (5), *Eleusine* (4), *Digitaria, Pappophorum, Saccharum* (3), *Cenchrus Ischaemum, Elionurus, Gracilea, Erianthus, Oryza* (2); 32 genera with 1 species only.—Peculiar to W. Rajputana: 23 species, to Sind: 11, to the Indus Delta: 7, to Cutch: 9. Reasons for this distribution.—Origin of the grass flora. Its relation to other vegetation.

20. Invasion and succession along the Indus in the Indus delta.—*By* E. Blatter.

Peculiar soil and water conditions along the Indus.—Definition of invasion and succession as understood by the author.—Cases of invasion: *Tamarix Troupii* Hole (*T. gallica* of Indian Floras, not of L.), *Tamarix dioica* Roxb., *Acacia arabica* Willd., *Prosopis spicigera* L., *Populus euphratica* Oliv.—Regressive succession of the above species described. This regressive succession must be ascribed to the failure of the water supply in an arid climate. Regeneration under changed conditions.—Division of resulting forests into 3 belts according to distance from river:

1. *Populus-Tamarix* belt. 2. The *Acacia arabica* belt. 3. The *Prosopis spicigera* belt, always in very open order, occupying the highest and dryest parts, and covering the most extensive area of the three.

21. Observations on the adaptability of some Leguminous plants to certain kinds of soils.—*By* L. B. Kulkarni.

(1) *Zornia diphylla,* though freely growing on the grazing areas of shallow soils of the Deccan, does not grow taller than 4 inches and seeds rapidly; as the soil gets deeper and blacker in colour, the species gradually disappears and is replaced by *Cassia pumila* and is entirely absent on soil of more than 9 inches in depth where there is a dominance of *Cassia pumila.*

(2) The latter again gradually wanes in extent as the soil gets still deeper and blacker and is replaced by *Heylandia latebrosa* and on soil of more than 18 inches in depth *Cassia pumila* is entirely absent and *Heylendia* prevails.

(3) As the soil gets poorer again, in depth and colour *Heylandia* and *Cassia* gradually disappear and *Zornia* re-appears and dominates.

(4) *Zornia* and *Cassia* grow taller with more foliage and seed later near Bombay with heavy rain-fall (70″ per annum) thus proving the importance of the climatic rather than edaphic factors, mainly precipitation and humidity, for their full growth.

(5) *Heylandia latebrosa,* and *Indigofera glandulosa* though common on deep black soil of the Deccan are much more susceptible to drought, while *Indigofera linifolia* growing on the same kind of soil has proved drought resistant.

22. A reconnaisance of the semi-natural formation both sides of the railroad between Tejgaon and Tangi, near Dacca.—*By* H. K. Dutta.

Description of the formation, its locality, climate, nature of the soil, consociations, conspicuous subordinate species, invaders, other subordinate species and flowering time of the principal and subordinate species.

23. Some weeds quite recently introduced into the city of Madras.—*By* P. V. MAYURANATHAN.

There are about 57 non-indigenous weeds in the City of Madras. Of these 45 hail from Tropical America including the West Indies, four from Africa, one from Australia, two from Southern Europe, two from Upper India and the native countries of three are unknown. Among the American weeds the following are quite recently introduced.

Gomphrena decumbens Jacq. has overrun the whole of the city and suburbs and is rapidly advancing. *Croton sparsiflorus* Morung has taken a firm foothold on the shore near the harbour and has advanced up to the Basin Bridge Junction. *Portulaca pilosa* Linn. is a very familiar weed in flower pots and frequently makes its appearance on lawns or in the vicinity of villages. *Ipomaea quinquefolia* Griseb, has established itself near Adyar. *Melochia nodiflora* Sw. is much more than a casual weed, but its progress has been slow. *Evolvulus nummularius* Linn., though recorded from Bengal many years ago, has been quite recently introduced into this city. It is established on lawns underneath the shade ot trees in the Agri-horticultural Society's Gardens and from there has proceeded to the roadsides in the immediate neighbourhood. *Alternanthera echinata*, though one of the commonest weeds in Coimbatore and Bangalore, had not been collected from Madras until December, 1924. One or two patches of this weed grow near Kodambakam Railway Station.

24. The ecology of Bandra and its vicinity.—*By* B. N. VAKIL.

This small area of about nine square miles forming a corner in the south-west of the island of Salsette has a surprisingly large variety of formations. Rocky and sandy shores and back-water creeks afford interesting studies of littoral plants, mangroves, algae in rocky-pools and other types of halophytic communities. Again the hills in the area lend a different aspect to the vegetation. The rocky slopes and high level areas with their characteristic thorny shrubs present a contrast particularly to the mesophytic undergrowths of old plantations of coconut, mango and cashew. Low lying ground occupied by salt-pans and cultivated fields have an interesting weed-flora varying with every season. In monsoon, fresh-water ponds, tanks, ditches and rock-pools afford an interesting study of aquatic plants. The rice-fields, bunds, road-sides and grass-lands are in this season very rich in annual and perennial species; the growth-forms prevailing in the wet and dry seasons, being completely divergent, considerably change the landscape. This change is still more marked in the case of hills with their growth of deciduous trees.

25. Additions to the grass-flora of the Bombay Presidency during the last 17 years.—*By* C. McCANN.

T. Cooke's Flora of the Presidency of Bombay was finished in 1908. He mentions 253 species belonging to 76 genera, including cultivated species. In the meantime only 8 new species have been described. The author is able to add 6 genera and 54 species which had not been noted in the presidency before.

26. A problem of distribution, illustrated by the grasses of six localities in the Bombay Presidency.—*By* C. McCANN.

The grass-flora of six localities in the Bombay Presidency has been examined: Bombay, Khandalla, Poona, Mahableshwar, Panchgani, and Dharwar. Number of species observed in every locality: Khandalla (88), Poona (80), Dharwar (79), Bombay (70), Panchgani (69), Mahableshwar (49). Elevation. rainfall, and other factors are adduced for an explanation of the above conditions.

27. Endemic grasses of the Bombay presidency and their distribution.—*By* C. McCANN.

According to our present knowledge of distribution there are 21 endemic species. Systematic and geographical position of the endemic species. 8 species of *Andropogon* (20% of all the Bombay species) are endemic.

The author distinguishes two areas: The Bombay-Mahableshwar area and the Karwar-Badami area. In the fomer 7 species of Andropogon are found of which 6 belong to the section *Amphilophis*: *Andropogon compressus* Hook. f.; *Andropogon ensiformis* Hook, f.; *Andropogon filiculmis* Hook. f., *Andropogon odoratus* Dna. Lisboa; *Andropogon concanensis* Hook. f.; *Andropogon Woodrowii* Hook. f. Probable origin of these species. The other endemic species of little plant geographical interest at the present state of our knowledge regarding their distribution.

28. Ecology of *Shorea talura*.—*By* P. M. SOMASUNDARAN *and* S. MAHDIHASSAN.

Troup states that *S. talura* (*Silviculture of Ind. Trees*, Vol. I, p. 133) is a hygrophilous plant which accounts for its growing in moist localities in Mysore State. In such areas lac is not cultivated. All the plants and grasses associated with *S. talura* at Dorasanipalya near Bangalore where lac is grown belong to a typical xerophytic flora which brings it in line with other host plants of lac in different parts of India.

29. Study of the nuclear division (karyokinesis) in the root-tip of *Crinum asiaticum* Linn. by the Eosin-Hydrochloric Acid and Haematoxyline Method.—*By* G. P. MAJUMDAR.

To study the karyokinetic division of the nucleus this method was successfully introduced in the Post Graduate practical classes.

Material selected:—Root-tips of *Crinum asiaticum* grown as pot herb in the College Herbarium. The root-tips were collected at about 11. A.M. and after careful washing were fixed in 1% Chromo-acetic-osmic acid solution for about 20 hours. Then washed, dehydrated, embedded in paraffin and microtome sections were made. For details see Chamberlains "Methods in Histology."

Methods of Staining:—Keep the slide with the sections in saturated watery solution of Eosin for about 5 minutes. Put a few drops of 25%–50% solution of Hydrochloric Acid upon the slide so as to cover all the sections at the same time. The whole thing changes to a yellowish-brown curdled mass. Wash the slide under running tap water, the colour returns to a bright pink, wash it thoroughly. The nuclei and chromosomes have become brilliant pink. Put the slide now in dilute Haematoxyline, the cell-walls and the cell-plate, take the characteristic cellulose reaction. Dehydrate and mount in Canadabalsam. The whole process takes about 15 minutes and the stain is fairly permanent. Protoplasmic contents may also be stained by this method.

30. Life history of *Cedrus deodara*.—*By* Indar Nath.

The paper deals with the life history of *Cedrus deodara* as worked out from the material collected by Dr. W. Dudgeon at Mussoorie and kindly handed over to the writer by Dr. S. L. Ghose who got it from Professor W. T. Saxton.

It is shown that the life history resembles that of the allied genus *Pinus*—the chief differences being in the period of ripening seeds, the number of neck-cells and the stage in which the pollen is shed. The time taken for the complete development is about fourteen months only, viz. from the beginning of July, when the female cones are initiated to the end of September, next year, when the seeds are shed. Pollination takes place at the end of September, the pollen being three celled at the time of shedding like that of *C. atlantica* (Smith, Bot. Gaz. 1923). The nucellus and integument are initiated a little before pollination, i.e. about the middle of September, but the archegonium initials are not distinguished till the second week of May of the following year. The archegonia are apical in position and are 3–5 in number, the number four being commonest. The neck-cells of the archegonia are arranged irregularly in two or three tiers and are usually large in number, being as many as 16. Fertilisation takes place in the beginning of June and the first two divisions of the fertilised egg follow immediately. The embryogeny resembles that of the genus *Pinus* in detail, there being the same four tiers of four cells each. As in *Pinus* all the four embryos develop for some time but only one reaches maturity.

The vascular supply of the female scale and the bracts were also traced out and the two vascular bundles are shown to be quite separate and inversely orientated. The vascular bundle in the bract remains unbranched, but the one in the scale spreads out a little and then bifurcates repeatedly.

31. Further remarks on the male cone of *Cycas circinalis*.—*By* SHIV RAM KASHYAP.

An examination of several male cones of *Cycas circinalis* has revealed the fact that the arrangement of sporophylls on the axis is not quite continuous. The base of the cone bears a small cluster of sporophylls, above which the axis of the cone is more or less completely devoid of sporophylls forming a sort of stalk. Above this stalk the main body of the cone is met with. This arrangement is different from the one met with in the male cones of some other Cycads which have been examined, e.g., *Zamia mexicana*, where the sporophylls are arranged perfectly, continuously and compactly throughout. The significance of the interruption is discussed in the paper. Abnormal sporophylls are usually met with at the base of the main body of the cone in *Cycas*. More abnormalities have recently been found. Some sporophylls showed a distinctly and equally bilobed tip, thus resembling the sporophylls of *Ceratozamia;* in others the tip was forked twice. These abnormalities appear to be indications of even a more primitive character than those already described by the writer.

32. The development of the embryo-sac of *Eugenia jambolana* Lamk.—*By* N. K. TEWARI.

The writer in this paper gives a detailed account of the development of the embryo-sac to the study of which he was led on account of the phenomenon of polyembryony exhibited in this plant.

33. The archegonium, fertilisation and after in *Equisetum debile*.—*By* L. MOHAN LAL SETHI.

The development of the archegonium and the fertilisation in *Equisetum debile* have been studied in detail. Two neck canal cells have been found in the mature archegonium which is the usual number for all the species of the genus which have been studied so far. The two neck canal cells may lie one above the other or they may lie side by side. Very often intermediate stages between these two extreme cases are also met with i.e. one neck canal cell may be wedged in between the upper neck canal cell and the ventral canal cell.

To secure stages in fertilisation female prothallia were flooded with water containing a large number of sperms squeezed out from male prothallia. Such prothallia were fixed at intervals of 15 mins. at first and later after rather long intervals. A large number of sperms may succeed in entering the archegonium but only one has invariably been found within the egg. The sperm bodily enters the oosphere. The blepharoplast and cilia are apparently absorbed in the egg-cytoplasm. The oospore repeatedly divides and an octant results. In one case it was found that after the first division only one cell of the young sporophyte had divided and the separating wall formed was parallel to the first wall with the result that all the three cells were in the same straight line. Such an abnormal linear row of 3 cells, so far as the writer is aware, has not been reported for any Pteridophyte.

34. Partial wilting of *Hibiscus tiliaceus.*—*By* H. CHAUDHURI.

Wilting of newly formed twigs of *Hibiscus tiliaceus*, during spring and early summer has been observed annually in a couple of plants in the Lahore Botanic Gardens for the last three years.

It has been found to be due to an attack of a species of *Alternaria* and the same species has been found to cause great loss in Jasminum and Marigold beds in Lahore by causing dry rots of flower buds. No cross inoculation from Jasminum and Marigold succeeded though the disease in the last two plants are intercrossible.

When the young twigs are formed early in the season, they become wilted and gradually dry up. Only the twigs formed late in the season develop.

Young twigs, when placed in a filtrate in which the disease causing organism had grown for 12 days, showed wilting. The organism secretes a good deal of alkali—it changed the Coons' medium from PH 4·5 to 7·0 in 12 days' time, and the wilting is due to this alkaline secretion.

The organisms can penetrate through the young growing regions but not through older tissues. The fresh young spores cannot resist the summer temperature, hence cannot affect the late twigs. Fresh infection takes place from outside annually.

35. *Salsola foetida* with special reference to its galls.—*By* SHIV RAM KASHYAP.

Salsola foetida is very common in the neighbourhood of Lahore occurring on dry soil. The plant is very variable as regards its leaves. They are long and filiform in young plants, as much as 1/2 in. long sometimes, but become smaller in older branches, and in large plants on still older branches they are described as subglobose, but their shape is best expressed by the words plano-convex or concavo-convex in transverse section. The leaves on young branches are also hairy, the hairs become fewer higher up and ultimately the leaves are practically glabrous. The chlorenchyma is confined to the outer region on the convex side, the rest of the leaf being filled with large-celled parenchyma-water tissue—with one vascular bundle in the middle.

The size of the fruiting perianth is also variable, the diameter varying from 1/10 in. to 1/4 in.

In the light of the above observations and the remarks in 'Flora of British India' under *Salsola verrucosa* and the remarks in Parker's 'Forest Flora of the Punjab' under *S. foetida* it appears that the plant described by Boissier in 'Flora Orientalis' under *S. verrucosa* is probably the young plant, or the old plant with young branches at its base, of *S. foetida.*

The plant is always infested with ovoid galls at the tips of branches caused by the puncture of some insect. These galls consist of the swollen tips of the shoots covered with numerous crowded leaves which are long filiform and very hairy—thus resembling the leaves on young plants.

It is suggested that the long hairy leaves on the galls of *Salsola foetida* are due to arrested development caused by the substances secreted by the insect in the gall. They are thus like the juvenile leaves of the plant.

36. Observations on a disease of Jowar (*Sorghum vulgare*) caused by *Sphacelia* (Conidial stage of *Claviceps*). Some observations in the field and in the laboratory on a disease of Jowar known in Marathi as Chikatya or Sakharya are recorded.—*By* S. L. AJREKAR.

The disease is ascribed to the *Sphacelia* stage of a *Claviceps* (related to the Ergot of Rye) and the dark green, and sometime whitish, bodies which are developed in place of the affected grains are described as imperfectly developed ergot bodies, whose development has been interfered with by the fungus *Carebella* or a yeast respectively.

37. Teratology of Mango fruit.—*By* V. N. GOKHALE.

Two types of cases of abnormalities in Mango fruit were observed. These were very interesting though not rare.

The first type represented a twin fruit, with *only one* peduncle; the fruit contained a bilobed stone, but the seeds were separate inside.

The second type consists of a main big fruit, with one or two smaller ones adhering to it, like protuberences, near the peduncle which is single. Each one had a separate stone and these stones remained attached together by fibrous threads. The stones of the smaller ones were undeveloped containing undeveloped seeds.

Fruits of the first kind are obtained, and are likely to be developed, on any tree. Fruits of the second kind, however, have been found on only one tree upto now.

The first one is supposed to be a case of "*fasciation*" of ovules, whilst the second one appears to represent a polycarpellary nature of the pistil, showing thus tendency to reversion to primitive form of *Anacardiaceae.*

38. Heterophylly—a problem.—*By* G. P. MAJUMDAR.

Six cases of heterophylly are described of which 5 represent seedling stages. The seedlings produce in addition to the cotyledons simple leaves for sometime before compound leaves are given off. The sixth specimen (*Bryophyllum*) shows heterophylly with alternating seasons of the year i.e. produces simple leaves in summer and compound leaves in winter. Can it be that compound leaves are derived from the simple leaves under very adverse circumstances?

39. Modifications leading to tetramerous symmetry in the flowers of *Zephyranthus rosea.*—*By* V. P. VARDE *and* S. B. RANADE.

1. The flowers of *Zephyranthus rosea,* commonly called Zephyr flower or Gulchabu (Marathi) are usually trimerous in symmetry.

2. A few bulbs produced from March to October, 1925, some flowers which showed modifications and variations in the floral parts.

3. Even with the scanty material available for study, different variations following different lines could be traced.

4. The increase in the number of the members of the whorls leading ultimately by successive stages to complete tetramerous symmetry and a

tendency to polyphylly indicated by incomplete division of petals and by the formation of staminodes were the prominent variations.

5. The bulbs showing these variations are kept under observation and further results are expected.

40. Observations on the heterophylly in *Aralia sp.*—*By* N. K. Tewari.

This species of *Aralia* normally bears unifoliolate leaves. It has, however, been noticed to produce compound leaves with two or three leaflets. This fact is recorded.

41. A note on *Carica papaya.*—*By* S. C. Dixit.

Considering the history of the Papaya plant it is generally taken to be dioecious and, exceptionally, male plants bear fruits. In 1915 and 1923 Mr. Kulkarni showed the floral link between the unisexual flowers. He found cyclic development of different sex flowers. The writer of the paper attempts to trace the phylogeny, and shows male type of plant bearing hermaphrodite flowers to be primitive. They began to sport under domestication. Unisexuality is the latest phase of the separation of the sex. Cyclic reproduction being the intermediate step. The plant treated shows reversion, hence apparent sexual misrule. (1) Inflorescence, (2) its origin, (3) vestigeal structures, (4) aestivation, (5) floral link, (6) environment, (7) mechanical adaptations, (8) maturity of flowers are the points to show phylogenetic relations of the plant. Changed mode of pollination and some other points are taken to illustrate the possibility of further changes and modifications of the plant.

42. Some variations in the inflorescence of *Ricinus communis* Willd.—*By* W. V. Joshi.

The paper deals with the observations on flowering of the panicles of *Ricinus communis.* The inflorescence differs in nature having either all male, or female, or both types of flowers mixed together in the same inflorescence. Hermaphrodite flowers are occasionally found in any of the above types of inflorescences. Plants were also met with which had some characters of other allied species. Difficulties in crossing and selfing are explained.

43. Branching of the thalamus of a Rose.—*By* S. C. Banerji.

The flower-axis of a series of Rose-flowers borne by a potted plant between December, 1924 and February, 1925 exhibited branching. It bore a branch-flower at the axil of a partially phyllodied carpel. The latter behaved like a bract and thus shows its homology to a leaf. This phenomenon shows that the flower-axis is not always of limited growth, and that the gynaecium does not always terminate it (vide Gœbel's Organography Part II, pages 541 and 553.) The phenomenon disappeared with a change in the set of vegetative axes which started from the base of the plant in April 1925, after some more soil had been added to the pot and water given freely. Too much of cold and a limited supply of nutrition probably stimulated the thalamus to a temporary vegetative activity resulting in the production of a fresh flower. The mother flower and the branch-flower were effective and complete flowers in almost all the cases observed, and in this respect the phenomenon differs from recorded cases of teratological prolification in Rose.

An instance of a similar temporary reversion to vegetation of the flower-axis of a species of *Lycopodium* and its termination in a new flower is also recorded.

44. Report on the occurrence of *Equisetum debile* Roxb. on the sandy alluvial bank of a river in Pabna. Lower Bengal —*By* G. P. MAJUMDAR.

The occurrence of *Equisetum debile* Roxb. reported from Pabna, North Bengal. The plant was found growing along the sandy alluvial banks of a river.

45. The algal flora of the Bombay Island and its immediate vicinity in Salsette.—*By* V. N. HATE.

The paper is a preliminary report on the algal flora, marine as well as fresh-water, prevalent in Bombay and its vicinity. The families and genera more commonly met with among the *Myxophyceae, Chlorophyceae* and *Characeae* are recorded with about twenty-four names of the species belonging to the different families mostly of the first two groups.

46. A few parasitic fungi from Bengal.—*By* JATIS SEN.

This paper deals with the investigation of a few species of fungi which the writer has collected from different parts of Bengal. Successful cultures were obtained from some of them, a detailed study of which is in progress. The behaviour of *Pestalozzia theae,* which has been found to grow on three new hosts, has been studied in different cultures, and the different stages in its life history leading to the formation of conidia have been traced.

Some of the species have been found to grow on hosts not previously recorded.

47. Fresh-water algae of Manipur.—*By* KALIPADA BISWAS.

In this paper the author gives an account of some of the fresh-water algae of the Manipur valley, occurring in the running water of streams and rivulets as well as in the stagnant pools and lakes of the Manipur valley. The specimens were collected by the late Dr. Annandale and by Dr. S. L. Hora, Superintendent Indian Museum, in the year 1920, during their zoological excursion to Manipur; and was presented by the latter to the Botanical laboratory of the University of Calcutta, a few months ago. The typical species of stagnant waters, most of which belong to Conjugatae, form a contrast to those of the species found in the water of streams and rivulets which unite to form the Imphal river.

A few forms of both the stagnant water as well as of the swiftly running water including some of the new species will also be mentioned in the present paper.

48. Grazing indicators.—*By* L. B. KULKARNI.

Although scarcity of fodder is felt keenly for more than two decades, it is a pity that grazing in India is not yet considered as a distinct field for investigation as in the west.

The following are in the main grazing indicators observed by the writer during his work on the investigation on the renovation of the worn out pastures of the Bombay Deccan.

1. *Aristida funiculata.* This species has been observed as a distinct indicator of the poor rocky soil of the Bombay Deccan ; is the second stage in the usual succession of species on such soils; is preceeded by *Tripogon Roxburghii* and followed by *Andropogon contortus* (annual). Being xerophytic grows with the least quantity of moisture and is rarely eaten by cattle on account of its fine awns.
2. *Andropogon contortus.* (Annual) smaller and early grower. Similarly marked as an indicator of poor soil but a bit better than that described above ; it occupies the third stage in the succession of species on

such soils; and is followed as a further step in the succession, by *Andropogon contortus* (perennial). Being armed with awns, it is useless as fodder, except in young stage.

3. *Andropogon contortus* (Perennial). Taller and late grower. Generally occupies fairly good soils of the Deccan pastures is an indicator of over-stocking and over-grazing. A very good fodder but for the awns. Suppressed by cultivation.

4. *Rottboellia exaltata.* Usually found on heavy clay soils of the Deccan pastures is an indicator of imperfectly drained soil. Also found along the water channels in black soil indicating the stagnant condition of the soil. It disappears as soon as the physical condition of the soil is improved.

5. *Eragrostis cynosuroides* Beauv. and *Ischaemum rugosum* Salisb. Both are found on deep clay soil of the rice tract, indicating the imperfectly drained condition of the soil caused either by the impenetrable subsoil or the hardened surface layer on account of incessant over-stocking during the wet season.

49. A preliminary account of the investigation on "Agaru." —*By* S. R. BOSE.

Dr. Hooper, late reporter on economic products of India, has said in *The Agricultural Ledger* 1904, No. 1 that the wood of *Aquilaria Agallocha* under certain conditions becomes gorged with a dark resinous aromatic juice, that the portions thus impregnated constitute the commercial Agaru, which is esteemed in proportion as it abounds in resinous matter. In no other part of the tree is this fragrant resin deposited. The average yield of a mature tree is 6 to 8 lbs. and an exceptionally good tree may afford as much as Rs. 300 worth of Agaru. The exact cause of its formation has not been ascertained as yet

In March last Mr. F. Trufford, Conservator of Forests, Assam, very kindly sent me some pieces of fresh Agaru wood. About 200 sections from different parts of those pieces were made and were variously stained. Sections of this diseased wood shewed copious drops of yellow gum here and there. A fungus mycelium was found close to the clotted areas in several sections of the wood. In the different pieces the nature of the mycelium was the same closely septed hyphæ of darkish gray colour. Wood shewed delignification by patches, alternate dark and white areas; the general effect on the wood agrees in all particulars with that produced by wood destroying fungi on trees.

I have been able to get the gum culture of the fungus in sterilized medium, and to obtain its spore formation; it belongs to the group of *Fungi Inperfecti.*

It is now left to carry on the inoculation experiment on healthy *Aquilaria Agallocha* and to get the production of Agaru in it—that will be the confirmatory test.

50. Notes on *Fossombronia himalayensis* Kashyap.—*By* S. K. PANDE.

Fossombronia is a fairly large genus of which the only species known from India is *F. himalayensis* Kashyap.

The intermediate position of the genus between purely thallose forms on the one hand and the higher foliose forms on the other has induced the author to study the plant in some detail, especially as our knowledge of the Indian species is confined to Prof. Kashyap's brief notes published in the New Phytologist Vol. XIV No. 1. 1915.

The material under investigation was collected by Dr. B. Sahni from Mussoorie and Simla during the months of September and October in 1924 and 1925.

The sporophyte has a specially well-developed foot with the cells of the lowermost two or three layers very highly developed.

The point of main interest is the structure of the capsule wall which, so far as I know, has been described as two-layered with usually the inner layer having thickenings. Humphrey, however, describes thickenings also in the outerwall of *F. longiseta.* In the present species, though Prof Kashyap has described the wall as two-layered, I have found that the wall is sometimes three-layered with thickenings in the inner two layers.

In *Treubia insignis,* the largest of the dorsiventral *Acrogynae* the wall of the capsule is three—or four-layered with thickenings on the inner layers.

The sporophyte of *Fossombronia himalayensis* Kashyap thus occupies an intermediate position between that of *Treubia insignis,* on the one hand and the other species of *Fossombronia* on the other.

Presumably *Fossombronia* might have been derived from forms like *Treubia insignis* by a process of reduction as appears to be borne out by the structure of capsule wall in *F. himalayensis.*

51. Further studies of *Gnetum Scandens.—By* M. A. SAM PATKUMARAN.

.More than one embryo sac is formed in the nucellus. The lower portion of the embryo-sac is narrow. After the nuclear division, nuclei are arranged peripherally in the sac both in the narrow and in the wide region. After the entrance of the pollen tube, wall formation takes place commencing from the narrow lower region. This is also seen in the corners of the wide upper region. These cells are multinuclear in the beginning, but later on become uninuclear. The central portion of the sac is never filled up with cells. Long after the tissue formation the eggs are organised; and they are generally one or two in each sac. The egg cells are easily distinguishable on account of their large size. The male cells are seen for a long time by the side of the egg cell. After fertilisation there is no free nuclear division. A long suspensor with a proembryo at the end could be seen.

52. Some marine Siphonaceous Algae Colaba near Bombay.—*By* D. L. DIXIT.

The following species have been noted :—

From. Codiaceae—

1. *Codium* sp. The specimen combines the characters of *C. elongaturn* and *C. isthmocladuns.*

From. Canlerpaceae.

2. *Caulerpa taxifolia ;* only one specimen was obtained.
3. *Caulerpa cupressoides* var. ? ; numerous specimens obtained.
4. *Caulerpa racemosa* var. (*a*); resembles the variety *clavifera,* but the ramuli have a distinct constriction just at the junction of the apical globular portion with the cylindrical stalk-like part. It is regarded as a distinct variety.
5. *Caulerpa racemosa* var. *mumularia ;* shows striking variations from the type.

53. Seasonal variations in respiration in *Astocarpus Integrifolia.—By* R. S. INAMDAR *and* BHOLANATH SINGH.

In the course of investigations on the $\frac{\text{Anaerobic}}{\text{aerobic}}$ ratios of respiration in *Astocarpus integrifolia* already reported in the abstracts of previous meetings of this section, it was observed that seasonal change introduced profound changes in the respiration of the leaf in many ways. The present paper embodies the results of a thorough investigation of the problem in different seasons at Benares.

The methods adopted for observing anaerobic-aerobic respirations are already described. The main conclusions that can be drawn from an elaborate survey of the problem at different temperatures on starved and non-starved leaves are briefly summarised below :—

1. There is a general increase in the initial values of both the aerobic and anaerobic respirations as the season advances from May to January. The statement applies at all temperatures to both the starved and the non-starved leaves.
2. The effect of "time-factor" increases from May to January, the increase being greater in the case of starved leaves than in the case of non-starved leaves. During the summer season, however, the fall in respiration in time at higher temperatures does not at all follow the characteristic logarithmic curve of "floating respiration" but occurs in jerks at intervals. This is interpreted by us to mean that the summer leaves, both the starved and the non-starved, respire practically at the protoplasmic level, the fall in jerks being due to the partial destruction of the fundamental respiratory mechanism. This destruction is greater in the case of anaerobic respiration and also in the starved leaves.
3. The ratios of anaerobic to aerobic respiration at any given temperature vary from season to season, being, in general, lower at every temperature as the season advances from May to January. This is no doubt partly due to the differential effect of "time factor" on the two kinds of respirations as season advances. But there is also a suspicion that the initial increase in the two kinds of respiration as the season advances is not also proportional.

These and the previous results described already indicate that determination of respiratory intensity through CO_2 produced gives only a partial picture of the respiratory activity and that the genetic relationship of the two kinds of respiration, anaerobic and aerobic, as measured by CO_2 production, is perhaps not so direct as is usually assumed.

54. The absorption of CO_2 by potash solution with reference to the relation of assimilation to CO_2 concentration.—*By* R. S. Inamdar *and* Krishna Kumar.

When the first author was working as a research student at Cambridge it was observed that the relation of assimilation in land plants to CO_2 concentration did not follow exactly the "limiting factor" curve and that there was a deviation from direct proportionality just at the corner where CO_2 ceases to limit the activity and where some other factor, such as Light or Temperature, begins, to operate as the limiting factor. Subsequent to these observations facts are produced by Richard Harder and Professor J. C. Bose on water plants confirming the observations of the first author on land plants. The two authors have not, however, produced any plausible explanation of the deviations noted. The present investigation is an attempt to explain this peculiar behaviour in terms of diffusion phase of CO_2 and the assimilated products.

The relation of physical absorption of varying concentrations of CO_2 by potash solution was observed on different concentrations of potash. Since the concentration of potash had to be kept constant at any moment for purposes of absorption of CO_2 for one concentration of potash, the method of absorption adopted by Brown and Escombe for the purpose was found unsuitable for this series of observations. A special silver chamber was therefore devised through which a constant current of potash of known strength could be kept running while absorption of CO_2 was going on. The CO_2 absorbed was determined by drawing the current before and after absorption through Pettenkoffer tubes containing Baryta. The special commutator devised by Dr. Blackman was used for automatic change of tubes from hour to hour. The temperature was kept constant throughout the series of observations.

By varying the concentrations of CO_2 till the maximum absorption was obtained, an absorption curve for each concentration of potash is obtained. The curves so obtained at different concentrations of potash all show the characteristic deviation from direct proportionality shown by the leaf as the saturation limit is approached. It is, therefore, concluded that both this phenomenon and the peculiar behaviour of the leaf are due to the fact that as the "Saturation limit" of absorption with reference to CO_2 concentration approaches, the absorptive surface (the "active chloroplast surface" in the case of the leaf) available for absorption for the flow of CO_2 decreases relatively till the maximum possible absorption is reached for a given temperature and for a given concentration of absorptive surface (potash, or active chloroplast surface in the leaf which, according to Briggs, is determined by the available Light Intensity). Direct proportionality between assimilation and CO_2 concentration can only be expected so long as the number of absorbing molecules does not decrease relatively and that is possible only when the relative concentration of absorptive surface is considerably greater, presenting fresh surface for absorption always, or when there is a balance kept up between absorption and removal of absorbed products by translocation. The facts do not support Richard Harder's conclusions that the idea of Limiting factors does not apply to the influence of external factors on CO_2 assimilation.

This piece of research has been possible owing to the generosity of Raosahib Krishna Paul Singh of Awagarh who has granted a post M.Sc. Scholarship to the second author.

55. Methods of grass-land improvement. (A study in plant Sociology).—*By* G. M. CHAKRADEO, B.A.

As the result of laborious investigation carried on for a number of years, the following conclusions have been arrived at:—

(1) The previous work in the line fails to satisfy the test of science and experience.

(2) The ere-long preached method of cultivation and replacement with better species is futile.

(3) The spear-grass (*Andropogon Contortus*) has two strains of which the undesirable one can be wiped out by natural plant succession.

(4) The poor land, so called, is replete with many grasses of good fodder value, which are kept down by over use but which can be revived under protection alternating with cutting and grazing, or both.

(5) Ordinary methods of levelling assist land improvement, which results in a luxurious onset of better species of grasses in larger numbers and improved quality.

(6) Survey of the grass lands, selection of species, control of the grazing stock, disposal of the stored grass crop, discovering the natural divisions of the flora and adoption of varying treatment to each, according to the different nature of the soil and the species, are some of the wider aspects of grassland improvement.

(7) The measures advocated admit of practical application by Indian farmers.

Section of Geology.

President :—PROFESSOR B. SAHNI, M.A., D.Sc., F.G.S.

Presidential Address.

THE SOUTHERN FOSSIL FLORAS: A STUDY IN THE PLANT-GEOGRAPHY OF THE PAST.

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INTRODUCTION.[1]

It was not without considerable hesitation that I accepted the invitation to preside at the section of geology. For I am no geologist; and I knew how difficult it would be to justify my occupation of a chair which had previously been graced by men distinguished, alike by ability and achievement, in a field for the most part unfamiliar to me.

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[1] For the purpose of publication the text has been somewhat enlarged (with the addition of matter unsuitable for reading in an address); it has also been thought useful to insert references to literature. I welcome this opportunity of expressing my thanks to the authorities of the Geological Survey of India for the loan of literature, and especially

While, therefore, I am thankfully conscious of this high honour, I cannot help feeling that my standing before you this morning is somewhat in the nature of a trespass. But I find some encouragement in the fact that in recent years fossil plants have received an increasing share of attention and recognition at the hands of geologists—a fact which was signified in a most graceful manner by the recent election of a master palaeobotanist as president of the Geological Society of London.

Fossil plants represent the debt that Botany owes to Geology.

When, in the early years of the last century, the introduction of embryology opened up a new and essential point of view in our study of organic beings, it ushered in a fresh era in biology. Till then we had viewed the structure of plants and animals in the three dimensions of length, breadth and thickness; embryology showed us the individual in a fourth dimension, that of Time. Many of the structures and phenomena of life, whose significance would otherwise have remained obscure, thus revealed their true meaning in a consistent scheme of origin and development. Similarly, taking the present flora of the earth as an individual organism, botanists can scarcely afford to study it simply as it exists to-day, for they would thus obtain at best a sectional view. To the noble science of geology, then, we owe a veritable "Time Machine" with which, although we cannot follow Dr. H. G. Wells into the realm of the Future, we can at least obtain a glimpse into a romantic Past.

In return, the study of fossil plants has yielded results, some of them of a far-reaching nature, which the geologist cannot ignore.

CHRONOLOGICAL VALUE OF PLANT FOSSILS.

It is not for me to urge the chronological value of plant fossils. Opinion on the subject has apparently changed a good deal. There was a time, not so long ago, when perhaps most geologists looked upon plant remains with a scepticism verging on suspicion, as not to be relied on unless there was independent corroborative evidence. Geologists in India do not need to be reminded of the prolonged controversy over the question of the age of the Gondwana floras.[1] Almost to the last,

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for permission to examine the fossil collections at the Indian Museum, Calcutta.

[1] Feistmantel (1876), (1886), (1887), (1890); Blanford (1876), (1885); Oldham (1886), (1886*a*); Medlicott (1886); besides other papers.

Feistmantel stoutly held that the greater part of the Lower Gondwana rocks of India and other rocks correlated with them in the southern hemisphere were of mesozoic age. He had to yield in the end,[1] not because he had relied upon the wrong source of evidence but because, like Schmalhausen[2] in Russia he had misread[3] the evidence of the plant fossils.

There can, of course, be no doubt that the remains of land plants—and most of the known vegetable remains are those of land plants—cannot claim the same stratigraphical importance as marine animals. But all the more recent comprehensive works on fossil floras have tended to support the view that our conclusions as to the age of a plant-bearing stratum can be safely relied upon if we consider as a whole the assemblage of species in that stratum.

A source of error may still linger in exceptional cases, where a restricted area with special environmental conditions may have successfully harboured a flora markedly different from the general facies of the vegetation. Such cases are not unknown at the present day. Dr. J. E. Holloway,[4] describing the vegetation of Stewart Island (New Zealand), speaks of local conditions exceptionally suited to a luxuriant growth of mosses and liverworts, lycopods and conifers, rather than of angiosperms; and he makes the interesting observation that "the general appearance of the vegetation is suggestive of a past age when gymnosperms and pteridophytes were dominant rather than phanerogams."

But instances of this kind would scarcely affect the position. On the whole we may say that we are working distinctly towards a rehabilitation of fossil plants as geological time markers. This important result we owe—apart from living palaeobotanists—to the labours specially of Professor Zeiller, Dr. Nathorst and Dr. Kidston, the loss of all of whom we have had to deplore at such short intervals within the last few years.

That more and more of palaeobotanical work is now-a-days being undertaken by men who are primarily geologists is a fact much to be welcomed, for they are in a better position to study the floras in their natural occurrences than are the palaeobotanists, whose activities are only too often confined to the laboratory.

FOSSIL PLANTS AND PALAEOGEOGRAPHY.

The palaeogeographical aspect of fossil plants is more conjectural and beset with difficulties, though it is at the same time the more interesting aspect. Relying upon a variety of evidence which defies a just analysis by any one person, and of which an important part is the distribution of organic remains over the globe in strata of corresponding age, many a vision of the past geography of the earth has been pictured. These visions are necessarily vague, and opinion will always differ on the details, but even apart from detail there is a disagreement on such fundamental points as the primitive shapes of our continents and oceans.

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[1] Feistmantel (1889). So far as I know his latest views on the subject were given in this work, which left his hands subsequently to his Australian memoir, published in 1890.

[2] Schmalhausen (1879).

[3] Zeiller (1896): see also Zalessky (1925).

[4] Holloway (1918), p. 5.

Have the ocean basins been permanent features of the earth's surface, and our continents existed with practically unaltered outlines since the earliest days, or were the continents at one time broadly connected together in such a way as to allow free migration of land organisms? If there were such land connections, were they of the nature of bridging continents now lost in the sea, or were the continents, shaped as they are to-day, juxtaposed into one enormous land mass, the Pangaea of Wegener,[1] which subsequently split up into the present continents?

It is true that the evidence from the distribution of fossil plants played a great part in the formulation of the theory of bridging continents, a theory which for many years past has been regarded as well established on other grounds. But is the nature of this evidence such that it should exclude the newer hypothesis of a former direct contiguity of the continents? Or does the evidence perhaps point, as has actually been claimed,[2] more in favour of this hypothesis?

I confess that in choosing a subject for my address to-day, I had started with the hope—which I soon realised was a presumptuous hope—that by tabulating, in the form of parallel columns, the fossil floras of the southern lands and of India, it might be possible, in some measure to test directly the validity of the displacement theory. It was thought that if the theory was correct, a horizontal traverse through these tables at any particular level in the upper palaeozoic strata would show a much closer affinity between the floras of two regions once adjacent than might be expected in view of migration across a land bridge several thousand miles long. Perhaps one might even expect, at least in some cases, an affinity amounting almost to identity, for there was no reason to assume that the rifts had necessarily left intact the freshwater basins as represented by the plant-bearing strata.

But it was soon realised that the problem was not so simple. We are not yet in possession of sufficient facts, and opinion is by no means settled with regard to the correlation of some of the plant-bearing strata. In Wegener's reconstruction one looks in vain for two regions once contiguous but now separated by the ocean, of which the fossil floras are equally well known to form a fair basis for comparison. Thus the present southern coast of South Africa is supposed to have been contiguous with what is now Antarctica till the beginning of the Jurassic period, but while from South Africa we know a fairly extensive permo-carboniferous flora and an equally well-developed triasso-rhaetic one, Antarctica has yet little to offer in comparison, though the few types collected are otherwise of the greatest interest. What is now the east coast of Brazil, according to the displacement theory once fitted into the present west coast of the South African peninsula, and the connection is supposed to have persisted till cretaceous times; but our knowledge of the fossil floras of these two regions is too unequal to admit of any comparison at all. The same remark applies as between Australia and Antarctica.

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[1] Wegener (1924), where also see further literature.

[2] Wegener (1924), p. 85; Irmscher (1922); Köppen. u. Wegener (1924), pp. 43–54.

I cannot pretend to appreciate the whole evidence, but one may perhaps say that it is to the study of the southern glaciation, rather than to that of the fossil floras, that this remarkable hypothesis owes its main support. So far as palaeobotanical facts are concerned, it does not seem as if we are yet equipped for a direct attack upon the problem. It is at any rate safe to leave one's mind open on the matter. Under the circumstances I have thought it best, instead of attempting an excursion into more speculative regions, to content myself with the task of collecting, in the form of correlation tables, the more important of the older floras of the southern hemisphere. The subject is of special significance to us here in India, although we are situated north of the equator, for it was in this country that the great problems of Gondwanaland were first raised and discussed. In spite of the extensive literature that has grown up round the subject of gondwana floras during the past fifty years, the need for more detailed work is as keen as ever.

CORRELATION OF THE SOUTHERN FOSSIL FLORAS.

A few years ago, when it was my privilege to address the Botany Section of this Congress, I took the opportunity of making a hasty sketch of our knowledge of Indian fossil floras.[1] It is hoped that the tables now offered, inevitably of a provisional nature, may be of some use in facilitating comparisons, and serve at least to indicate the gaps which still remain in our knowledge of gondwana floras.

In the tables the more important palaeobotanical breaks are for the sake of clearness marked with bolder lines. The first of them is shown just above an important plant-bearing horizon in the Falkland Islands. Here, about 15 years ago, Dr. Halle[1] collected what is in all probability a southern outpost of the *Psilophyton* flora, which is well known to have been widely distributed in the northern hemisphere. In Australia the line separates the marine lower or middle devonian rocks of New South Wales (the Murrumbidgean Series of Suessmilch[2]) from the Lambian Series, containing undoubted members of the *Archaeopteris* flora. The position of the line as shown in South Africa, between the Bokkeveld and the Witteberg Series, although not based on the plant evidence, may be accepted in view of the close stratigraphical and faunal resemblances between South Africa and the Falklands. demonstrated by Dr. Halle and Dr. J. M. Clarke.[3] Although both the devonian floras have not yet been discovered in one and the same country in the South, the position of our first datum line may be taken as fairly well established on comparative grounds, and we may hopefully look forward to see further evidence forthcoming, specially from South Africa, of an extension of the *Psilophyton* flora into the southern hemisphere.

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[1] Sahni (1922).

The second break marks the advent of the *Glossopteris* flora, and is by some placed in the upper carboniferous, by others at the base of the permian.

A third lies near the base of the rhaetic, but the exact horizon is an open question: it may even have varied from one country to another—a point that will need some discussion.

Above the jurassic there is a fourth and very important break, which still hides from us the secret of that "abominable mystery," the sudden appearance of a large and well-differentiated angiosperm flora. But with this we shall not here concern ourselves.

I shall now touch briefly on a few of the more interesting points concerning the different floras, taking where possible the Indian floras as a basis for comparison.

(*a*) *Pre-Gondwana Floras.*

Silurian.

The silurian records are few and uncertain. In India some doubtful plant-remains were collected by the late Sir Henry Hayden[4] in the lower silurian of Spiti. In the southern hemisphere the only species, if it is a plant at all, is *Spirophyton cauda-phasiani* originally described as an alga from New South Wales by de Koninck.[5]

Lower and Middle Devonian.

Palaeobotanically the lower and middle divisions of the devonian are too similar to allow of a separate treatment; and the similarity which the comparatively few plant remains so far known from the southern hemisphere present to corresponding records in the north, seems to point to the existence of a widespread and possibly cosmopolitan flora of a rather uniform character. This archaic flora, consisting for the most part of lepidodendroid plants and Psilophytales, was called by Dr. Arber the Psilophyton flora, after the characteristic genus *Psilophyton* first described by Dawson from the devonian of Canada. Whether or not any gymnosperms existed at the time in the northern hemisphere, none have so far been recorded from the south; nor is there, to my knowledge, any evidence of ferns or fern-like plants. It is a curious fact, noticed by many, that most of the plant remains of this period fail to show the flat expanded surface which is generally associated with "leaves" in the ordinary sense.

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[1] Halle (1911), p. 19.

[2] Suessmilch (1922), p. 54.

[3] Halle (1911), pp. 17, 27-28.

[4] Hayden (1904), pp. 24, 32.

[5] de Koninck (1876-77), pt. IV, fig. 1.

In India no plant-bearing strata of this age have yet been discovered, and the only Australian record known to me is *Lepidodendron australe* which occurs in the Tamworth beds of New South Wales,[1] in association with radiolarian shells. These marine beds belong to the lower or Murrumbidgee series of Suessmilch, regarded by him (p. 58) as of lower devonian age but possibly extending into the middle devonian.

Of special interest is a small collection of fossil plants described by Dr. Halle[2] from the devonian rocks of the Falkland Islands. Apart from some obscure lycopod remains comparable to the South African species *Cyclostigma irregulare* (Schwarz) there are some forked leafless axes with terminal sporangium like swellings. As Professor Seward[3] says these fossils strongly remind one of the Psilophytales, a group of plants hitherto known only from the northern hemisphere, and there is a possibility that the sporangia were columellate like those of *Hornea*. A close resemblance is also shown with *Hicklingia Edwardi*. more recently described by Kidston and Lang[4] from the Middle Old Red Sandstone of Scotland.

The Bokkeveld series of South Africa shows a far-reaching similarity to the early devonian rocks of the Falkland Islands. The discovery of Psilophytalean remains in the South African Devonian would then not come as a surprise, although so far as I know the only fossil plant yet recorded from the Bokkeveld series is *Cyclostigma Leslii* (Seward). This plant closely resembles the northern form *C. irregulare* (Schwarz) from the Witteberg series. The devonian fauna of the Falklands, curiously enough, exhibits a much closer affinity with that of the Bokkeveld series of South Africa than with that of the far nearer Devonian rocks of South America.

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[1] Suessmilch (1922), p. 59.

[2] Halle (1911), p. 19.

[3] Seward (1923), p. ci; also Seward and Walton (1923), p. 316.

[4] Kidston and Lang (1923).

Upper Devonian.

Above the middle devonian strata occurs the first important break in the land flora. It separates the older Psilophyton flora from the equally widespread Archaeopteris flora characteristic of upper devonian and later times. In the southern hemisphere this flora shows the best development in Eastern Australia, specially in Victoria and New South Wales where, apart from *Archaeopteris* itself, *Cordaites* and *Sphenopteris* are represented. Another form described by W. S. Dun[1] as a species of *Pecopteris* (*P. ? obscura* Dun) has been closely compared by Professor Seward[2] to the North American upper devonian species *Barinophyton Richardsoni.* We are thus here not only introduced to the gymnosperm phylum but also meet with a fair proportion of fern-like plants. But the commonest plant is *Lepidodendron australe* McCoy which in the New South Wales beds has also been found associated with marine shells of upper devonian age.[3] The exact relation between this plant and the European species *L. nothum* of Unger are not quite clear. Carruthers[4] referred some specimens from Qeensland to *L. nothum* and Feistmantel[5] did the same with others from Queensland and New South Wales, at the same time (p. 136, pl. 1. figs. 5, 6) assigning to *L. australe* some fragments from Victoria. From Feistmantel's figures these latter specimens appear to differ somewhat in the more central position of the leaf trace scar but I cannot say how far this may be due to different degrees of decortication. In any case several authorities, including McCoy, R. Etheridge Jr. and Dr. Kidston have concurred[6] in the opinion that the Victorian and Queensland plants all belong to one and the same species, namely, *L. australe* McCoy—a view also supported more recently by Dr. Gothan.[7] It would seem then that the northern species *L. nothum* does not figure in the Australian flora.

In South Africa the only strata comparable to the upper devonian of Australia are the Witteberg Series of Cape Colony which overlie the Bokkeveld beds, containing an early devonian fauna. The palaeobotanical evidence is yet inadequate for fixing the exact age of the Witteberg beds, but such as it is, it indicates an upper devonian rather than a lower carboniferous horizon. This view is corroborated by the associated remains of Eurypterids[8] which are similar in surface markings to those of a northern upper devonian type, *Eurypterus hibernicus* Baily from the Kiltorkan Beds of Ireland. It is interesting to find fossils strikingly similar to these widespread and undoubtedly pre-Gondwana types occurring in the Coal Measures of Brazil[1] in association with Lower Gondwana plants. But of these I shall have more to say at a later stage.

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[1] Dun (1897), p. 2, pl. x, figs. 1-2.

[2] Seward (1923), p. cii.

[3] David and Pittman (1893).

[4] Carruthers (1872), p. 353.

[5] Feistmantel (1890), p. 138.

[6] See footnote by R. Etheridge in Feistmantel (1890) p. 137.

[7] Gothan (1915), p. 228.

Seward (1909); Woodward (1909).

Time after time we see evidence of the wide distribution of the forms of life preceding the great revolution which towards the close of the carboniferous period so considerably changed the face of the southern flora.

Lower Carboniferous.

Plant-bearing rocks which are probably of lower carboniferous age are known in the southern hemisphere from New South Wales and Victoria on the one side of the pole and in Peru and Argentina on the other.

In 1915 Mrs. E. M. Osborne[2] announced the discovery near Barraba (New South Wales) of a petrified stem with attached leaf-bases belonging to the extinct family of Zygopterid ferns, till then only known from the northern hemisphere. The petioles of the same species, later described by myself[3] from near Mount Tangorin in New South Wales, showed a structure analogous to that of European and Siberian species of *Clepsydropsis.* The age of the Australian beds (the Barraba Series of Prof. W. N. Benson[4]) in which Mrs. Osborne's fossil is said to have been found *in situ*, is not known with certainty. It is either upper devonian or lower carboniferous, but the association with *Lepidodendron australe* would seem to favour the former horizon; the beds, moreover, are said to be directly overlain by strata with a lower carboniferous marine fauna. On the other hand, although the Mount Tangorin specimen was not found *in situ*, it did not show signs of having been transported any great distance, and the locality is mapped by Dr. Walkom[5] as carboniferous.

The Burindi series of New South Wales has by Professor David[6] been provisionally regarded as homotaxial with the Lipak series of Spiti. In the Burindi beds Dr. Walkom[7] has recognised a small flora including the characteristic lower carboniferous fossil *Lepidodendron Veltheimianum*, a familiar European form. Rocks apparently of the same age in several localities in New South Wales have yielded other species of Lepidodendroid plants (for example, *L. Volkmannianum*, *L. cf.*

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[1] White (1908).

[2] Osborne (1915), p. 727. (*Postscript.*—Although this fossil was reported to have been found *in situ*, I understand from a recent letter from Prof. W. N. Benson that there is still some room for doubt on the matter. At the same time Prof. Benson writes (31-3-1926) that a large specimen of *Clepsydropsis* has recently been found *in situ* in the Kuttung Beds near Mt. Tangorin).

[3] Sahni (1919).

[4] Benson (1913), p. 495; (1922), pp. 106, 204.

[5] Walkom (1913), pp 150-51.

[6] David (1920), p. 293.

[7] Walkom (1920), p. 282.

dichotomum, and *Cyclostigma australe* Fst.), identical or closely comparable with European types. The last-named plant has been compared by Professor Seward to *C. Kiltorkense* Haught. and *C. Leslii* Sew.

In Victoria the characteristic upper devonian species *Lepidodendron australe* persists into the Avon Sandstones which are strongly uncomformable to the middle devonian strata in that region, and have moreover been assigned by McCoy on palaeontological evidence to a lower carboniferous horizon. In the Mansfield beds of Victoria *L. australe* is found in association with lower carboniferous fish remains.

The Drummond series of Queensland has yielded only poorly preserved plants, and some of the determinations are open to doubt, but the general aspect of flora, as D. Walkom[1] says, is distinctly carboniferous.

From Peru only about a dozen species of palaeozoic plants are known, but the naming of several of them is uncertain. Dr. E. W. Berry[2] asserts that the flora indicates a Westphalian age. But Steinmann's[3] determinations of the same collection, as well as some further specimens recently examined by Professor Seward[4] from the same region, point to a lower carboniferous horizon, several of the species being comparable with typical culm plants from Europe.

As. Dr. Szajnocha[5] showed, the Retamito formation of Argentina probably corresponds to the culm of Europe. The well-known culm plant *Asterocalamites scrobiculatus* is here the commonest fossil. A fairly well-preserved fragment compared to *Lepidodendron nothum* Unger is more probably identical with the East Australian species *L. australe* characteristic of upper devonian and lower carboniferous rocks. The specimen figured by the late Dr. F. Kurtz[6] as *Botrychiopsis Weissiana* somewhat suggests the genus *Rhacopteris* which attained a great development during the middle carboniferous period.

Middle Carboniferous.

A few badly preserved plants discovered by the late Sir Henry Hayden[7] in the Po Series of Spiti were compared by Zeiller to some fern-like species from the culm of Eastern Australia and Germany. Although the palaeobotanical data are too meagre to serve as an index of age, there is other evidence[8] tending to show that the Po Series belongs to a middle carboniferous horizon. So far as I know the only southern flora specifically referred to that age is that of the Kuttung series in the Hunter River district of New South Wales. Dr. Walkom[9] here records several species of *Rhacopteris* and other fern-like plants. specially

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[1] Walkom (1919), p. 7.

[2] Berry (1922), p. 194.

[3] Steinmann (1910).

[4] Seward (1924), p. lxxiv.

[5] Szajnocha (1891).

[6] Kurtz (1894).

[7] Hayden (1904).

[8] Middlemiss (1910).

[9] Walkom (1920), p. 285

Aneimites ovata (McCoy), which according to Dun,[1] is identical with the *Rhacopteris inaequilatera* of Feistmantel. That the transition from the lower carboniferous is not a sharp one is shown by the persistence of *Asterocalamites scrobiculatus* as well as the presence of species of *Lepidodendron* and *Cyclostigma*, both genera well represented in the lower carboniferous rocks. A feature of great interest in the Kuttung series is the association of glacial beds, which would thus represent the earliest traces of ice action in the southern carboniferous.

(*b*) *Gondwana Floras.*

It is now generally agreed that through the long ages represented by the rocks of the upper devonian and earlier carboniferous, the original cosmopolitan flora probably evolved along similar lines in the two hemispheres Then the balance was disturbed by the great southern cold period which ushered in the *Glossopteris* flora and led to the differentiation of distinct botanical provinces.

Advent of the Glossopteris flora.

There seems no doubt that the general lowering of the temperature, which must have long preceded the ice itself, had already initiated this change. In an admirable little volume recently published Dr. Gothan[2] has given reasons for the view that the climatic conditions governing the *Glossopteris* flora were not appreciably different from those that obtained during the formation of the Coal Measures of Europe. But of course this view cannot refer to the origin and early history of that flora, which must have been intimately connected with the cold. The close relation of the Gondwana plant beds with the glacial deposits over enormous areas would alone impose caution against any other interpretation. At Bacchus Marsh, in Victoria, *Gangamopteris* and *Schizoneura* have long been known to occur in beds interstratified with the glacials. Then, a few years ago, came the important discovery, by Mr T. N. Leslie[3] of *Gangamopteris* immediately below the Dwyka tillite in South Africa. This was followed by a similar discovery by Dr. du Toit[4] at another locality in the same region. While no one would seriously maintain that a vegetation such as that of our Damuda coal measures was in any sense a glacial flora, the facts available distinctly support the old view that the marked change of climate had directly to do with the extinction of many of the older forms of life. As for the new arrivals, we know nothing of the stages by which they made their appearance. This part of the drama has been enacted behind the scenes. We here lose thread of the story.

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[1] Dunn (1905), p. 157. [2] Gothan (1924), pp. 153–55.

[3] Leslie (1921), p. xxiii; see fig. 23, pl. XXII in Seward and Walton (1923).

[4] du Toit (1924), p. 75. The locality is near Strydenburg.

The Northward migration.

Once established, the newcomers could hold their ground even after a return to a warmer climate. Not only this, but at the height of their development we find them invading the northern territory, where their remains are now being so ably investigated by Dr. Zalessky and his colleagues. So far as I know there are no traces of ice action in the rocks underlying the Gondwana plant-beds of Angaraland.[1] Nor need we expect any such traces if the plants are immigrants from the south, already used to the ameliorated climate.

Relations with Angaraland.

The relations of the flora of Angaraland with those of Europe and the Southern Continent would form a most interesting study. Ever since Amalitzky's discovery of *Glossopteris* in northern Russia the view has grown that between the northern and southern continents there must have been some means of communication for the spread of land plants. As Dr. Zalessky says[2] there must have been either an isthmus or a dense archipelago across the old Mediterranean Sea, and he speaks of a possible Angaro-Gondwana continent. But the data are insufficient to show the lateral extent of the connection. Dr. Zalessky has, most generously, sent at my request a map of Russia and Siberia showing the different localities where fossil plants of a Gondwana facies have been found. In order to see clearly the space relations of this Angara flora with those of Europe, China and India, I have here plotted these localities on a map of Eurasia.[3] The wide eastward extension of the Angara flora is remarkable. So far as our present knowledge goes Kashmir lay on the main route of the northward migration. But possibly there were other routes, through China; but of this we shall hear from Dr. Halle, whose work on the flora of the great Chinese coal-fields is shortly to be published. Meanwhile Dr. Fritel has quite recently announced the important discovery of a lower gondwana flora from the Chan Si province of N.E. China.[4]

Age of the Kashmir plant beds.

The relative proximity of Kashmir to the southernmost Angara locality raises the question of the geological age of the Kashmir beds. I am not competent to express an opinion on this point. The Russian deposits are regarded by Dr. Zalessky[5] and others as permian. Dr. du Toit has, moreover, from other considerations, hinted[6] that the date of the Indian glaciation may have been a little later than that of the South African, which he places in the upper carboniferous. If this was so, and assuming that the trend of the ice was northward, it is more likely to have been true of Kashmir than of peninsular India. May it be that we have here in reality a southern outpost of the Angara flora ? The small flora so far discovered in Kashmir is scarcely a reliable basis for generalization, but I would point out the close similarity of *Gangamopteris kashmirensis* with the plant described by Dr. Zalessky[1] as *Glossopteropsis angarica* which also I believe is a *Gangamopteris.* It was originally assigned to that genus by Dr. Zalessky himself.[2] The typically northern genus *Psygmophyllum*, which is well represented in the Angara flora, was apparently also abundant in Kashmir, the only other known gondwana species being South African.[3] A fragment of a pinnate leaf from the Golabgarh Pass on the Pir Panjal has been referred by Professor Seward[4] to *Callipteridium* and compared to the northern Permian species *Callipteris conferta.* Lastly, on the authority of Dr. Sir A. Smith Woodward[5] we know that the fish and labyrinthodont remains from the Gangamopteris beds of Kashmir belong to typically lower permian genera (*Amblypterus* and *Archegosaurus*). It is much to be hoped that Professor B. K. Bose[6] of Jammu, who has recently discovered fresh plant-bearing localities in Kashmir, will be able materially to add to the few plants so far collected from this important region.

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[1] Gothan (1912), pp. 427-28.

[2] Zalessky (1918), p. 5.

[3] Reproduced here with the kind permission of Dr. Zalessky.

[4] Fritel (1925).

[5] Zalessky (1925).

[6] du Toit (1921), p. 225.

Admixture of "northern" types in Gondwana floras.

A few words may now be devoted to the occurrence of so-called northern types in the southern gondwana beds. Although these types have generally been called northern I believe it is not unlikely that at least some of them are hardy survivors (and in part descendants) of the cosmopolitan life of pre-Gondwana times. While a further knowledge of the earlier southern forms is necessary to settle the point, a few instances may be given in illustration :—

(i) To start with an instance from the animal world, the Witteberg series of South Africa has yielded remains of Eurypterids[7] very similar to some which Dr. White[8] figured from the gondwana coal measures of Brazil. These Brazilian fragments, which, in ignorance of their exact nature, Dr. White referred to a new genus *Hastimima,* occur in the Joachim Branco bed along with typical members of the Glossopteris flora.

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[1] Zalessky (1918), pl. 8, fig. 1-2. [2] Zalessky (1912), pl. 7, fig. 2.

[3] Unless, as suggested by Prof. Seward (1919, p. 85), the leaves referred to *Rhipidopsis ginkgoides var. Süssmilchi* from the base of the Narrabeen beds of New South Wales are also those of a *Psygmophyllum.*

[4] Seward (1912). [5] Seward and Smith Woodward (1905).

[6] B. K. Bose (1924), p. 218.

[7] Seward (1909) ; Woodward (1909). [8] D. White (1908).

(ii) In the Cruz de Caña mine in the Argentine province of San Juan, Dr. Kurtz[1] recognized an association of *Rhacopteris*, a pre-gondwana genus, with *Glossopteris* and *Gangamopteris*. As Dr. White[2] says "if the species are correctly determined and are really contemporaneous the association is of the greatest interest" although I venture to think that the conclusion he draws does not necessarily follow. He sees in this association a direct and conclusive proof of "an early date for the advent of the gondwana flora in South America." I prefer to regard the *Rhacopteris* as a survival from an earlier flora. Although undoubted traces of a *Rhacopteris* flora have not yet been discovered in South America Szajnocha[3] referred to that genus some badly preserved fragments from Retamito in Argentina. I may add that the lower carboniferous plant referred by Kurtz to his new genus *Botrychiopsis* resembles a *Rhacopteris*. The *Rhacopteris* flora is also well represented in eastern Australia.

(iii) Leaves similar to those of *Cordaites* have been recorded from Devonian beds in New South Wales and Victoria. The wide-spread southern form *Noeggerathiopsis Hislopi* is also found in the succeeding gondwana beds in New South Wales. No one at present doubts that it is *Cordaitean* even if it may not actually be a species of *Cordaites*.

(iv) Of all the so-called northern types found in the gondwana beds the lycopods were the most widespread and abundant, and the same is true of them in the pre-gondwana rocks. In the gondwanas they have been found, as is well known, in South America, South Africa, and with some doubt in India,[4] although Australia has till now failed to show any traces. From different horizons below the gondwanas they have been recorded from Argentina, Peru, the Falkland Islands, South Africa, and Australia. The Brazilian gondwana species *Lepidodendron Pedroanum* has also been recorded from the Retamito formation (lower carboniferous) of Argentina, while from Peruvian rocks which are certainly older than the gondwanas specimens have been referred to *L. Veltheimianum*, a species which the late Dr. Kidston regarded as indistinguishable from *L. Pedroanum*. Similarly *Cyclostigma Leslii*, described by Professor Seward from the Ecca beds (lower gondwana), can be traced back into the Bokkeveld series of the same region. It is also probably related to *C. irregulare* (Schwarz) from the Witteberg series of South Africa, and has been compared by Professor Seward to *C. australe* from the carboniferous of Australia (Queensland and New South Wales).

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[1] See Bodenbender (1902), p. 12.

[2] White (1908), p. 351.

[3] Szajnocha (1891), p. 7.

[4] Seward and Sahni (1920), p. 15, figs. 28, *a-c*, pl. II (*Bothrodendron sp.* ?)

Both in South America and in South Africa, then, closely related or even identical lycopod forms can be traced upwards across the great hiatus.

My point is that when we speak of an admixture of northern forms in the gondwana floras there is a tendency to lose sight of the fact that identical or similar forms already existed in the south. It is, therefore, quite natural and, in fact, easier, to trace to *them* the origin of the admixture than to postulate a a southward migration from the northern continent. It may be that our fuller knowledge of the northern floras makes us turn to them for clues which are near at hand in the south.

Unmixed floras of the "northern" type in the southern hemisphere.

Of more than ordinary interest from a plant-geographical point of view is the occurrence, in the southern hemisphere, of restricted floras purely of the "northern" type, without any trace of the gondwana element. Although reports of such occurrences have more than once been made from South Africa[1] they have always been contradicted.[2] But no such doubt exists in the case of the rather sensational discovery recently made in central Sumatra. From here Dr. Jongmans and Dr. Gothan[3] describe a genuine flora of the West European type regarded by them as of upper carboniferous (Stephanian) age. The find is of sufficient importance to have justified a special visit to the locality by the Dutch palaeobotanist Dr. O. Posthumus. I am indebted to Dr. Posthumus for a few further particulars. In a recent letter from Selemboekoe (October 22, 1925) he writes that the fossiliferous series contains a horizon with permian brachiopods, shales with plant impressions, and sandstones with silicified wood. He believes the beds to be of permian rather than upper carboniferous age, for apart from the brachiopod evidence he has found plants referable to *Callipteridium*, *Taeniopteris* and *Walchia*. These are in addition to those described already, which include such typical Coal Measure genera as *Lepidodendron*, *Sphenophyllum*, *Stigmaria*, *Calamites*, *Pecopteris* and *Cordaites.* Seven out of the nine determinable species are identical with or allied to well-known European forms. The locality lies a little south of the equator and midway between the classical gondwana districts of India and Australia. Yet in the flora there is not a trace of the gondwana element. As Dr. Gothan remarks,[1] these plants can either represent a southward extension of the northern flora, which shows affinities with the Gigantopteris flora of China; or they may be only a persisting relic of the pre-gondwana cosmopolitan flora, preserved in the seclusion of a biological asylum.

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[1] Grey (1871); Ziller (1883).

[2] Jones (1884); Seward (1903), p. 88; Gothan (1912*a*), pp. 36–39; Gothan (1914); Seward (1914), p. 28; Seward (1924), p. lxxxiv.

[3] Jongmans and Gothan (1925).

Residual types.

Speaking of residual types one is reminded of the survival of isolated members of the Glossopteris flora through the period when the general aspect of the vegetation was undergoing another radical change. In India, as we have seen, the palaeontological break between the Panchet series and the Rajmahal series is all but complete[2]: scarcely a species is common to the two. The statement that *Glossopteris* has been found in the Rajmahal stage has never been substantiated. It is true that the Parsora beds show an admixture of lower gondwana species with others characteristic of a later period, but the meagre flora so far known still bears a palaeozoic rather than a mesozoic aspect, and the change to the Rajmahal flora is very abrupt.

In several districts of Gondwanaland floras essentially of a mesozoic aspect, but with a considerable residual element, have been preserved in rocks variously classed as triassic and rhaetic. They are known from the rhaetic of Tonkin, from the Burghersdorp and Molteno beds of South Africa and with some doubt from the rhaetic of New Zealand and of the Republic of Argentina. In Australia no undoubted members of the Glossopteris flora have yet been found in association with a mesozoic flora

New Zealand a part of the southern continent.

Some doubt has centred round this question in regard to New Zealand because the late Dr. Newell Arber[3] referred some *Glossopteris*-like leaves to a new genus *Linguifolium* on the ground that they were devoid of anastomosing veins. In the absence of clear traces of the Glossopteris flora he was led to believe that New Zealand had never formed part of the gondwana continent. Professor Seward,[4] however, and following him Dr. Gothan,[5] has expressed the opinion, with which I fully agree, that Dr. Arber's conclusion was based on an exaggerated importance given to a minor difference. Absence of anastomoses between the lateral veins has on another occasion also been made the chief ground for generic separation. The lower gondwana leaves referred by Feistmantel[1] to the new genus *Palaeovittaria* are in general shape similar to *Glossopteris* and *Gangamopteris*, a resemblance noticed by Professor Zeiller who also described *Palaeovittaria* from the rhaetic of Tonkin.[2] A close relation is shown to some leaves from the Permian of Siberia, originally figured by Schmalhausen[3] under the name *Zamiopteris glossopteroides*, and recently transferred by Dr. Zalessky,[4] I think justly, to *Gangamopteris*, a genus not easily distinguished from *Glossopteris*. In their relation towards *Gangamopteris* and *Glossopteris*, then, *Palaeovittaria* and *Linguifolium* are almost "in the same boat." I recently examined the type specimen of *Palaeovittaria* and found to my surprise that the several leaves, figured by Feistmantel as separate, radiate from the apex of a stem which shows the characteristic signs of *Vertebraria*. The mode of attachment is also rather suggestive of some figured specimens of *Glossopteris*. In Feistmantels's figure the stem has for some reason been left out. The question now arises whether even *Palaeovittaria* is to be respected as a distinct genus. I hope to deal with this point more fully elsewhere, but what I have said certainly gives some indirect support to the view that Arber's *Linguifolium*, if not identical with *Glossopteris*, is at any rate closely related to it, and may safely be regarded as a member of the Glossopteris flora.

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[1] Jongmans and Gothan (1925), p. 301.

[2] Blanford (1885), p. 42; Sahni (1922), p. clxiv and Table I.

[3] Arber (1913), p. 123; (1913*a*), p. 347.

[4] Seward (1914), pp. 38-39.

[5] Gothan (1924), p. 149.

Steinmann has recently recorded *Linguifolium* from Chile[5] and Walkom[6] has added a new species from Tasmanian beds referred to the rhaetic, but the integrity of the genus is questionable.

While in these countries the *Glossopteris* flora died out gradually and in some places co-existed with a well-developed mesozoic flora, Australia has not so far yielded any evidence of such an association. In this connection the New South Wales beds are specially instructive because here the Upper (or Newcastle) Coal Measures (almost certainly of permian age and homotaxial with our Damudas) pass upward, mostly in a conformable sequence, into the Hawkesbury series, of triassic age.[7] Although the upper limit of the permian is generally drawn at the top of the Bulli Coal Seam, palæobotanically the base of the overlying Narrabeen stage of the Hawkesbury series is still a part of the Palæozoic. A few plants described by Dun[8] from a horizon several feet above the seam form an unmixed *Glossopteris* flora. In the higher beds of the Narrabeen stage, on the other hand, we suddenly come upon a well-developed mesozoic flora without any sign a lower Gondwana admixture.[1] A closer examination of the intermediate beds may yet reveal a mixture of the two.

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[1] Feistmantel (1881). p. (91), pl. XLIV*A*., fig. 1.

[2] Zeiller (1903), p. 82.

[3] Schmalhansen (1879), p. 80, pl. XIV, figs. 1-3.

[4] Zalessky (1918), pl. XVIII, figs. 1-2.

[5] See Gothan (1924), p. 149. I have not been able to see Steinmann's paper.

[6] Walkom (1925 *a*), p. 81 and fig. 11 p. 83.

[7] Suessmilch (1922), p. 154 and table p. 129.

[8] Dun (1910), (1911).

There can be little doubt about the triassic age of the main flora of the Narrabeen beds. The Molteno beds have generally been classed as rhaetic[2] but a quantity of fresh material of plants collected by Dr. du Toit and now under investigation by him inclines him to place them as not younger than Keuper.[3] This view is confirmed by Dr. Haughton's work on the vertebrate fauna of the Stormberg series.[4]

Age of the Parsora Beds of India.

These considerations raise anew the question of the age of our own Parsora beds, provisionally classed by Dr. Cotter as rhaetic.[5] As I have suggested elsewhere[6] the flora, from the little we know of it, contains a strong palæozoic element. In addition, there are *Thinnfeldia odontopteroides* and *Danæopsis* (? *Thinnfeldia*) *Hughesi*, both consistent with a triassic age. The only newer element is a doubtful *Cladophlebis denticulata*. Above the Parsoras is a marked palaeobotanical break. Unless the discovery of further specimens turns the balance, the flora must represent a very early stage in the triasso-rhaetic transformation. Unfortunately the field-relations are obscure, and the only fossil evidence, so far as I know, is that of a few plants. Any conclusions as to geological age must therefore be of a tentative nature. But with this proviso we would perhaps be equally justified in classing the beds as upper triassic. The available facts, at any rate, do not seem to conflict with such a view. Moreover, India then falls into line with Professor Seward's generalisation of 1903 that there was a world-wide change in the plant kingdom at the dawn of the rhaetic period. We have no reason to think that the Indian flora did not keep pace with the great wave of transformation which at the time was sweeping the world.

It hardly needs to be said that the reference of the Parsora stage to the triassic only adds force to Dr. Cotter's suggestion that these beds should be included in the lower gondwana series.

Conflicting evidence of plants and animals.

Before bringing this address to a close I may be allowed to touch briefly upon a subject which cannot be without concern to the stratigraphical geologist, namely, a certain conflict, in part perhaps real, between the testimony of plants and animals as indices of geological time. In his famous address at Montreal, on Homotaxis as illustrated by the Indian Formations, W. T. Blanford drew attention to a number of instances, especially from India and Australia, in which the evidence from the two sides apparently led to paradoxical results. And he summed up the evidence, such as it then was, in the following words:[1] "In the Gondwanas we have a "Rhaetic flora overlying a Jurassic flora, and a Triassic fauna "above both. In Australia we find a Jurassic flora associated "with a Carboniferous marine fauna, and overlaid by a Permian "fresh-water fauna." But we now know that the discrepancies were, at least for the most part, apparent, not real, being based chiefly on mistaken views regarding the ages of the gondwana floras. It is ungrateful now to recall the errors that befell the pioneers in the field, for it is difficult correctly to visualise the state of knowledge at the time. But if, in concluding this address, I advert to an unfortunate episode in the history of palæobotany, I do so because I believe it was this circumstance, more than anything else, that undermined the confidence of geologists in fossil plants as indices of age. But happily—"by degrees we reject the old slippery stepping-stones that "so often toppled us into the stream, and foot by foot we "build a secure bridge over the waters of ignorance."[2]

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[1] Walkom (1925).

[2] Seward (1903).

[3] du Toit (1919); (1924), p. 75.

[4] Haughton (1924), p. 490.

[5] Cotter (1917)

[6] Sahni (1922), pp. clxii-clxiii

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[1] Blanford (1885), p. 50.

[2] Bather (1920), p. 10.

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Explanatory Note on the Correlation Tables (Charts I–IV).

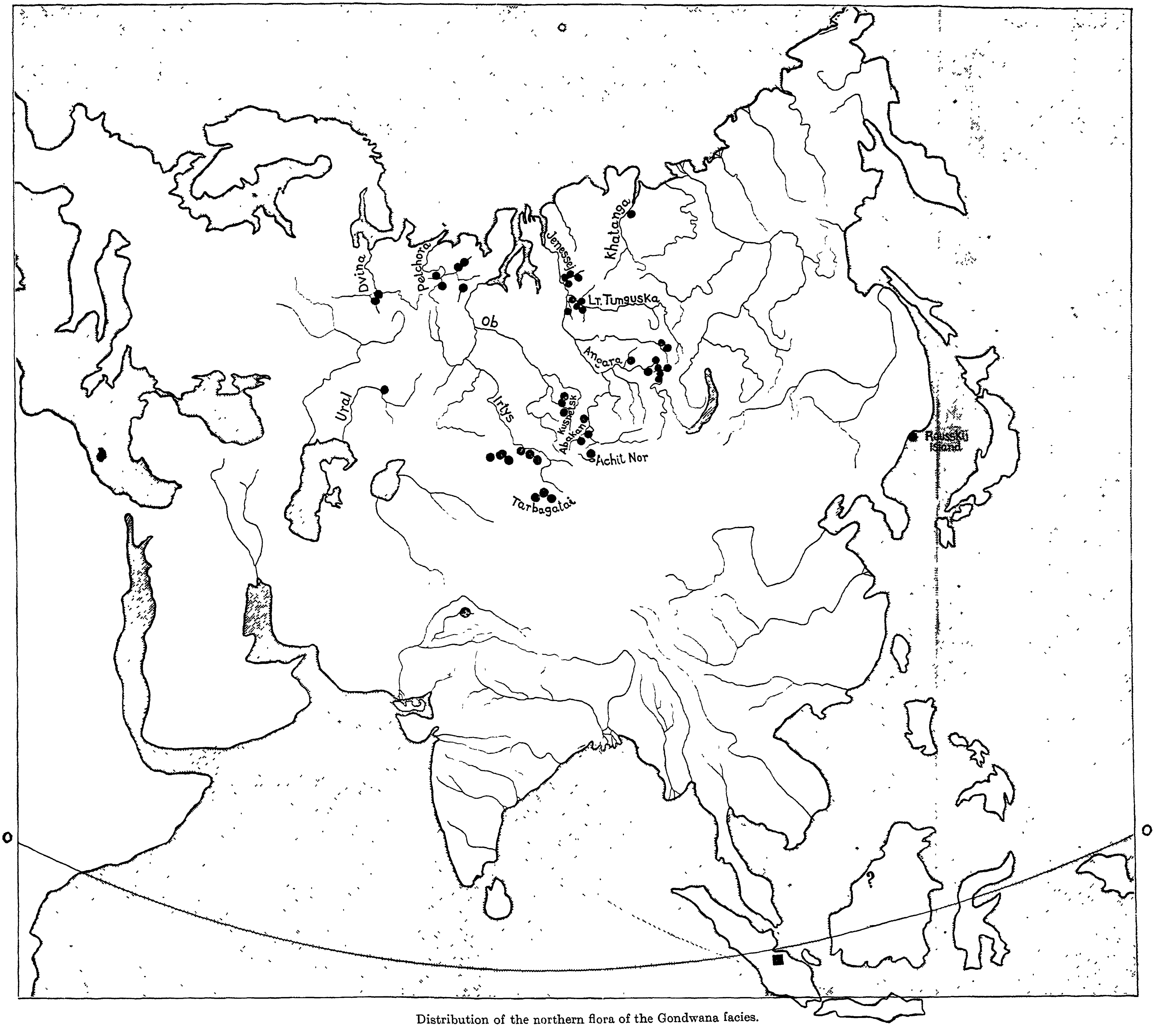
I cannot introduce these tables without a word of apology to fellow-workers in some of the countries whose floras are here included. For in a sense I have encroached upon a domain which they are the best fitted, severally, to deal with. For this reason, although an attempt has been made to include all the more important records I cannot claim that the tables are complete. There is much that future work, even a revision of some of the older material, will make it necessary to alter; and this, I believe, is especially true of the Argentine floras which, owing to the untimely death of Dr. Kurtz, had to be published in a form that leaves much to be desired. The Indian floras, of which a provisional list was published in 1922, have been omitted as they are now under revision by myself. The great majority of the plant names have, of course, been entered in the tables as published, but in many cases, so far as the scattered literature has been accessible to me, the figures have been compared with identical or allied species described elsewhere. In a few instances, where the names clearly needed revision, they have been altered so as to bring them into line with the modern nomenclature, and also to avoid conveying a false impression of affinities. But where I have been in doubt with regard to the identities of plants, or where specially marked resemblances have been noticed, by myself or by others, with species described under different names, the comparisons suggested have been placed within square brackets. Inverted commas indicate determinations which are open to doubt, or where the names appear to need revision. In a few places, where a record has appeared to me to be based on doubtful or otherwise inadequate material I have not hesitated to omit it. Lastly, in explanation of these tables, I will add that those who know the labyrinthine ways of palaeobotanical nomenclature will, I am sure, recognise the inevitable handicap under which one works in making comparisons of species from descriptions and figures alone, for access to the actual specimens is of course, as a rule, out of the question. For this reason I have in many cases hesitated to record comparisons.

Through Dr. A. L. du Toit's kindness I have been able to make use of a revised list of the Karroo floras which he generously sent at my request in anticipation of the publication of his book on the Geology of South

Africa. His list of Molteno species is here reproduced almost verbatim; but it does not include some new species awaiting description by him. A fuller (provisional) list of the Stormberg flora by Dr. du Toit, including some of these unfigured species and a few others, is given in Haughton (1924), pp. 323-324. I am also indebted to Dr. A. B. Walkom, and to Mr. J. H. Reid of the Queensland Geological Survey, for information concerning the localities and horizons of some of the plants recorded from that state, and to Dr. O. Posthumus for unpublished information concerning his discoveries in Sumatra.

Explanation of Map.

Distribution of the northern flora of the Gondwana facies (from a map kindly supplied by Professor M. D. Zalessky). The Gangamopteris beds of Kashmir are also indicated. The square mark in Sumatra shows the recently discovered upper palæozoic flora purely of the west European type. The query mark in Borneo refers to the unconfirmed record (Tenison-Woods, 1885) of a Glossopteris flora in Sarawak. There is a similar unconfirmed record from Southern New Guinea (see Geogr. Journ., Vol. 38, p. 485, 1911). The Chinese records are not shown.



Distribution of the northern flora of the Gondwana facies.

Abstracts of Papers.

1. Note on the occurrence of Gypsified Marl and Alveolina-bearing Limestone beds in the Gypsum Zone overlying the Salt-deposits of Bahadur Khel.—*By* D. N. WADIA *and* L. M. Davies.

A fair amount of Alveolina-bearing limestone and marl are found intimately associated with the upper part of the Gypsum of Bahadur Khel, in the form of discontinuous laminæ, lenticles, or small cores ("islands") of limestone in the midst of gypsum masses. This limestone is strongly dolomitic and unfossiliferous, but in parts of the gypsum there are enclosed larger lumps of unaltered or partly gypsified limestone which contain *Nummulites* and *Alveolina.* These beds are the probable equivalents of the Alveolina limestone bed of the adjacent Kohat section, the Lr. Laki age of which is established on satisfactory fossil evidence. The Kohat and Bahadur Khel sections show a close parallelism with respect to the remaining strata.

The origin of the upper part of the gypsum of Bahadur Khel is taken to be secondary, but the change is believed to be due not to the surface alteration produced by oxidized pyrites, but to a contemporaneous or pene-contemporaneous action of $MgSO_4$–salts of a desiccating inland sea-basin on the calcareous deposits that were being laid down on its floor. The close association of dolomite with gypsum cannot be otherwise explained. The underlying rock-salt and massive gypsum were original chemical precipitates from the same sea at an immediately preceding date.

2. Ranikot beds at Thal.—*By* L. M. DAVIES.

The author records his discovery at Thal (lat. 33°20' N.), 60 miles WSW of Kohat, of beds containing *Nummulites planulatus*, a species never before found in India north of lat. 25°50' N., and described by Vredenburg as being confined to a relatively small area in Western Sind. He further records the discovery, together with *N. planulatus*, of another early Eocene foraminifer, *Siderolites miscella*, which accompanies *N. planulatus* in Sind; and also the following species of corals: *Isastraea punctata, Astrocœnia cellulata* and *Astraea morloti*, all of which characterise the same uppermost zone of the Ranikot in Sind.

The *planulatus* beds at Thal are found to underlie blue-grey clays, locally representing the basal Laki "Meting Shales," which are capped in turn by Laki limestones which apparently correspond to the mid-Laki "Alveolina Limestones" of Sind.

Beneath the *planulatus* beds come several hundred feet of unfossiliferous clays, then another fossiliferous zone with the following species: *Semicassis phillipsi, Turritella angulata, Turritella diastropha, Mesalia mecquenemi* and *Astrocœnia blanfordi*, which apparently indicate a very low horizon in the Upper Ranikot; the first 3 species being peculiar to the lowest zone of the same in Sind, while the last named species is the only one which has not previously been found below the second lowest zone. Beneath these beds in turn comes a great mass of black-weathering sandstones surmounting red and green splintery shales, which appear to represent the Lower Ranikot, and overlie in turn reduced representatives of a peculiar limestone-breccia bed, which at Hangu—30 miles to the East of Thal—is found to represent a basal Eocene horizon.

There appears, therefore, to be no doubt whatever that not only do Ranikot beds exist in India far north of the region to which they have hitherto been supposed to be confined, but that the Kohat-Thal area presents, in some respects, a more complete series of these earliest Eocene horizons than has hitherto been found elsewhere.

3. Stratigraphical distribution of petroleum in Burma.—*By* A. S. SUBBAIYER.

Oil occurrences in Burma are confined to two geological epochs; the Oligocene and the Eocene., in local nomenclature the Sitsayan stage beds (Oligocene) and the Tabyin and Pondaung stages (Eocene) embrace all the known oil horizons. The Oligocene oil has been under incessant exploitation as in the widely known fields Yenangyaung, Yenangyat, Singu, and Thayetmyo and Minbu. The prospects of exploiting Eocene oil are not so well known and examination of Eocene strata for this purpose is only of recent date.

From regional field work by the writer in the Pakokku district the Eocene-Pegu succession of strata is embodied in this paper, and for purposes of comparison vertical sections of the sequence of succession in the Pakokku hill tracts, Yenangyat and Singu are also presented. As little is known of the economic possibilities of Eocene oil occurrences, brief remarks are made to record the structural peculiarities in the Eocene strata, which consists in diversity and variation from the typical anticlinal folds, but, nevertheless, is quite favourable for retention of oil pools.

The paper concludes with the observation that there is enormous extent of unexplored territory and thickness of strata still awaiting attack, in examination of which proper interpretation of subsurface geology and structure is of great importance.

4. Petroleum production and reserve in Burma.—*By* A. S. SUBBAIYER.

The subject is considered in a purely subjective aspect, i.e., the production statistics are studied in relation to the past history of the producing fields and their future.

Production figures are alone considered insufficient data for this study.

The producing fields are divided into three groups according to their situation and importance as producers.

The production from the fields, Yenangyaung, Yenangyat, Singu, Minbu, and Thayetmyo, are from Oligocene oil sands. The production from Upper Chindwin, Kyaukpyu, and Akyab fields are from Eocene strata.

The production figures indicate that Yenangyaung and Singu have paramount influence over total production, that Minbu and Upper Chindwin, being new fields, have begun to show perceptible influence since 1922, and that Yenangyat, Akyab, and Kyaukpyu are decadent fields. About Thayetmyo one has to remain sceptical.

Judging the fields individually by the production figures of each, the Yenangyaung field, the foremost amongst producing fields and the oldest known also, has suffered from improper estimation owing to lack of co-ordinated work in that field, which is the consequence of unhealthy and ill-directed competition. The Singu field, and to some extent, the Minbu and Upper Chindwin fields offer a pleasant contrast and show that only by sound understanding of inherent conditions of a field and by organised, progressive and co-ordinated work, the potential value is realizable and there can be approach to correct estimation of its value.

The production curve for Yenangyat is typical of an exhausted field.

Upper Chindwin is to be considered as the bright forerunner of Eocene oil fields awaiting exploitation.

Except in the case of Yenangyaung, Singu, Yenangyat, and Minbu more detailed scientific work still remains to be done.

The producing fields as a whole form but a small fraction of the whole oil region in Burma. And even in these fields exploitation has been only from very limited depths. The reserve is vast and the resources of oil for the whole province are yet unexplored. The problems awaiting efficient investigation are finding out subsurface extension of the oil zones, location of subsurface structures, and the preparation, by field work, of a regional map intended to show the varying thickness of overlying deposits which have suffered from contemporaneous erosion in places.

5. A preliminary note on the geology of the extinct volcano of Mount Popa, Burma.—*By* H. L. CHHIBBER *and* L. DUDLEY STAMP.

This communication is a continuation of the work of the authors and their colleagues on the late tertiary and post tertiary volcanic rocks of Burma. The areas already described are Kabwet, north of Mandalay (*Trans. Min. Geol. Inst. India*, 1925) and the volcanoes of the Lower Chindwin (*Indian Science Congress, Benares*, 1925).

Mount Popa forms a conspicuous landmark in the heart of the dry belt of Central Burma and rises to nearly 4000 feet above the surrounding plains. The central mount consists of a roughly circular crater, of which the north-western side has been blown away. The outer slopes, especially of the higher part, are precipitous and strewn with blocks of lava and ashes. Surrounding the central mount is a plateau of lava and agglomerate, more resistant to weathering than the surrounding sedimentary rocks and so forming a plateau nearly 1000 feet above the plains. To the south-west of the main peak is the isolated crag of Taunggala which appears to be the neck of a subsidiary volcano. Ten miles to the south of Popa is the Taungni massif, composed mainly of partially silicified tuffs, whilst 12 miles to the south-west are the Kyaukpadaung Hills, also composed of silicified tuffs. The sedimentary rocks to the east of the Popa mass are Peguan, to the west Irrawaddian. The exact sequence of the volcanic rocks is not easy to determine. The oldest rock seems to be an agglomerate capped by a well bedded dark coloured andesite which flowed southwards some 15 miles from Popa. Only patches of the originally continuous sheet now remain. The coarse whitish tuffs of Taungni and the silicified tuffs of Kyaukpadaung appear to be next in age. Later in age are the volcanic agglomerates and the later andesite which now makes up the main mass of the mountain. This lava is lighter in colour than the earlier andesite and has conspicuous phenocrysts of augite. Large areas of the country surrounding the volcanic rocks are covered with volcanic detrital alluvium. There is some evidence to show that the earlier volcanic rocks were contemporaneous with the later Irrawaddian rocks and shared in the folding to which the latter were subjected. The later flow appears to be recent and there may be some truth in the legend that activity only ceased in historic times.

The southern part of the area had been mapped by the Geological Survey and the authors wish to acknowledge their indebtedness to these maps. So far as the authors are aware no description of the volcanic rocks and their microstructure has been previously attempted.

6. The petrography of Green Island and the Amherst coast, Lower Burma.—*By* L. DUDLEY STAMP.

Green Island is a small isle, crowned by a light house, which lies off the coast of Lower Burma on the southern side of the mouth of the river Salween. The Geology is magnificently displayed on the rocky shores of the island and along the adjacent mainland. Perfectly seen one has a beautiful example of igneous intrusion accompanied by extensive assimilation of the country rock and contamination of the igneous magma. The country rock, away from the intrusions, consists of a soft, dark grey shale and may be seen on the foreshore near Amherst town. The strike is roughly north and south and the beds are highly inclined—approaching vertical. Going westwards is equivalent to going downwards in the succession as far as the intrusive rocks are concerned. A short distance west of Amherst, the highest members of the intrusive series are seen; they consist of quartz veins. A few hundred yards further west veins or thin sills of coarse muscovite-quartz pegmatite appear and the country rock has been altered to a soft biotite schist. These rocks are seen just west of Pagoda Point. Slightly lower, sills of aplite appear and the next stage (seen at the northern end of Green Island, or southwards along the mainland from Pagoda Point) is a wonderful succession of lit-par-lit injections of aplitic granite into hornblende-biotite schists. In the middle of Green Island the association between invading and invaded rocks becomes still more intimate and has resulted in the production of a banded intrusion gneiss. At the south west end of Green Island one passes into what may be called the "normal" intrusive rock—a hornblende biotite granite. This rock has, however, been greatly contaminated by the absorption of great blocks of the country rock. All stages in the assimilation of the blocks of black hornblende biotite mica schist are seen. One remarkable feature is the presence of a white reaction border between the black xenoliths and the dark grey granite.

7. Diagnostic value of hinge characters and evolution of cardinal process in the Terebratulid genus *Carneithyris* Sahni.—*By* M. R. SAHNI.

(1) The type of hinge-parts and cardinal process is of considerable importance in the study of Chalk Terebratulids.

(2) The cardinal process shows a distinct line of evolution in the genus Carneithyris, expressed by :—

(*a*) Change in shape from pyramidal to globular.
(*b*) Greater and greater development of its apophyses.
(*c*) Change in position with respect to the surrounding hinge-parts.

(3) These changes are repeated in the phylogeny as well as in the ontogeny.

8. The chemical composition of Cordierite from Madura district, S. India.—*By* V. S. SWAMINATHAN.

As some strikingly fresh chips of Cordierite were found near Madura showing the characteristic pleochroism, it was considered worthwhile to chemically analyse the mineral with a view to determine :—

(1) The formula of the Mineral.
(2) The state of oxidation of Iron.
(3) The nature and amount of water present.
(4) The ratio MgO bears to FeO.
(5) and finally the cause of the colour of the mineral.

Duplicate analyses were made throughout. Separate portions of the sample were taken for estimating the amounts of FeO, MnO, H_2O. FeO was determined after the method suggested by Hillebrand, and MnO according to Walter's Colorimetric method. 1 gr. sample was subjected to increasing temperatures, till constant weights were obtained at each step, for the determination of water.

The results of the analyses are given in the following tables :—

Specific gravity of the mineral 2·621

Constituents	Mean of 2 analysis.	Molecular ratios.		
SiO_2	50·11	0·831	0·831	10
Al_2O_3	31·46	0·308	0·310	4
Fe_2O_3	0·34	0·002		
FeO	5·35	0·074	0·342	4
MnO	0·40	0·005		
MgO	10·63	0·263		
H_2O	1·64	0·102	0·090	1
	99·93			

Water Temp.	105°C	300°C	Dull Red.	Full Red	Total.
Loss in	Nil	0·65	0·89	0·08	1·62
Weight.	Nil	0 64	0·92	0·09	1·65

The following conclusions are drawn from the preceding tables.

(1) The ratio $SiO_2 : R_2O_3 : RO : H_2O$ is nearly equal to $10 : 4 : 4 : 1$, in other words the formula of Cordierite becomes $H_2O\ 4\ (MgFe)\ O, 4\ Al_2O_3, 10\ SiO_2$.

(2) Nearly all the iron is present as protoxide, a conclusion in harmony with that arrived at by O. C. Farrington.

(3) The high temperature required to drive off the water shows that it is all constitutional.

(4) The ratio MgO bears to FeO in this case is 7 : 2, other published analyses show either this ratio or the other one 6 : 3.

(5) The violet colour of the mineral and its pleochroism is due primarily to the MnO present invariably though in small quantity.

9. The caves of Sewri.—*By* JAYME RIBEIRO.

In recent years a large number of natural caves has been discovered in the City of Bombay. The main geological formations of the Island consist of the dark, hard, brittle, basaltic trap forming the topmost stratum of the rocks of Bombay and the grey soft, scoriaceous trap lying under the above directly or with the aqueous strata or a thin layer of ash sandwiched between them. There is another, intermediate rock, grey in colour with darker spots, forming by itself a ridge comprising the Nowroji Hill in Dongri and the Sewri Cemetery Hill in Sewri. Excepting a few small cavities occurring in the upper trap, the caves are found in the lower and the Sewri Cemetery Hill traps. Those in the former seem to be due to the wearing out of the softer portions of the rock by mechanical or chemical action of running subterranean waters, while the caves in the latter are evidently large bubble cavities produced by the vaporisation of the moisture and some of the constituents of the organic matter of the pre-existing fresh-water beds, which were evidently dissolved by the lava flow.

The biggest cave in the first series was 17 ft. long, 10 ft. wide and 9 ft. high. Nearly all the caves contained very pretty crystals of laumontite and calcite. The most important find was, however, of graphite in the largest cave.

In the second series the caves were disposed in tiers one above the other in roughly horizontal lines. There were four such lines open at one and the same time showing about 30 mouths in a length of about 100 feet. The lowest line of the caves was about 90 T.H.D. (Town Hall Datum=100, mean sea level=80·25). These caves were uniformly higher at the east end and tapered towards the west giving an impression that the huge bubbles were dragged westwards by the plastic lava. The largest cave found in this series was over 20 ft. in length, 10 ft. in width and 8 ft. in height.

The most important, and the one that caused some stir, content of some of the caves was, however, bitumen in a variety of forms ranging from the hard, brittle, black bitumen through the rubbery elaterite to the semi-liquid jelly. It is practically certain that the bitumen was the result of the large amount of animal and vegetable matter that was incorporated in the aqueous beds that were broken up and dissolved by the lava flow, but whether this bitumen was evolved in the caves themselves or was introduced from outside is difficult to say. Most of the caves were dry when they were opened out. In one instance the water found in one of the caves was distinctly salty the sodium and potassium chlorides being 280 grains per gallon, and in another case there was a very large amount of sulphates, 44 grains per gallon, in the water.

The various minerals obtained from the caves are incorporated in the "Jayme Ribeiro Collection of Rocks, Minerals and Fossils from the Island of Bombay" in the Prince of Wales Museum of Western India

10. A revision of the Indian Fossil Conifers in the collection of the Geological Survey of India.—*By B.* SAHNI.

The author is engaged on a revision of the Geological Survey's collection of fossil plants at the Indian Museum, Calcutta. The present paper deals with the Indian fossil Conifers. A part of the collection was recently revised by Professor A. C. Seward and the author (Palæont. Indica N.S., VII. 1920). The present work includes a number of specimens newly added to the collection and some others (chiefly the "duplicates" of Feistmantel which had not been revised since 1883). Apart from the fossil woods (to be described later) the following is believed to be a complete list of the determinable Indian species.

The geological ranges of some of the species have had to be revised partly in view of the new determinations, but chiefly in the light of the numerous "duplicates" examined. A number of specimens have yielded cuticular preparations. A few new fructifications have also come to light, notably some well preserved petrified cones from the intertrappean cherts of the Chhindwara District, collected by Mr. Crookshank of the Geological Survey of India.

Lower Gondwana (*Upper Carbonif. and Permian*)

1. Buriadia heterophylla (Brongn).
2. ? Voltzia heterophylla Brongn.
3. [Moranocladus] Oldhami (Zeiller)

Upper Gondwana (*Jurassic and Lower Cretaceous*)

4. Elatocladus plana (Fst.)
5. E. conferta (Morris)
6. E. tenerrima (Fst.)
7. E. jabalpurensis (Fst.)
8. Retinosporites indica (O. and M.)
9. ? Desmiophyllum sp. (="Podozamites lanceolatus" etc).
10. Araucarites latifolius Fst.
11. A. cutchensis Fst.
12. A. macropterus Fst.
13. Torreyites constricta (Fst.)
14. Brachyphyllum expansum (Sternb.)
15. B. mamillare L. and H.
16. B. rhombicum (Fst.)
17. B. Feistmanteli (Halle)
18. Pagiophyllum sp. α [cf. P. peregrinum (L. and H.)]
19. P. sp. β [cf. divaricatum (Bunb.)]
20. P. sp. γ [cf. P. setosum (Philips)]
21. P. sp. δ

22. Coniferocaulon sp.
23. Conites rajmahalensis sp. nov.
24. C. sessilis sp. nov.
25. C. sp. [? cone of Brachyllum expansum (Sternb.)]
26. C. cutchensis sp. nov.
27. C. sp. cf. Strobilites laxus Sow.
28. C. sp. cf. Strobilites anceps Berry.
29. Strobilites Sewardi sp. nov.
30. Obscure female fructification, attached to shoot.
31. Carpolithes sp.

Jurassic of Burma

32. Pagiophyllum burmense sp. nov.
33. Cupressinocladus sp. α
34. C. sp. β (with cones)

Intertrappean Beds (Cretaceous.)

35. Conites sp. (silicified female cones)

11. A new form in Staurolite Crystal.—*By* S. L. BISWAS.

A new form (011) in Staurolite crystal is described and recorded.

12. A short note on the cretaceous fauna of the Khasi hills, Assam.—*By* HEM CH. DAS-GUPTA.

The paper contains an account of 16 species of fossils from the cretaceous beds of the Khasi hills. Of these 16 species three are new to science. The fossils show that, as already established by Dr. Spengler, they are of upper senonian age with an admixture of Indo-Pacific and Mediterranean elements, and possibly represent a stage corresponding with the top of the Ariyalur beds.

13. Petrological notes from Bhavanagar, Kathiawar.—*By* HEM CH. DAS GUPTA.

This paper contains a detailed description of the different kinds of igneous rocks met with in the area.

14. Notes on the Upper Cretaceous rocks near Ariyalur-Trichinopoly Dt.—*By* L. RAMA RAO.

The paper classifies and describes the different beds constituting the upper cretaceous rocks near Ariyalur, and records some interesting points relating to the lithology, stratigraphy and palæontology of these rock formations.

15. A new method of field investigation applicable to oil territory in Burma.—*By* A. S. SUBBAIYER.

The new method which receives elaborate attention in the text is the application of fixed carbon ratios in surface survey of possible oil territory where oil and coal both occur in proximity.

This is an entirely new study lacking in publicity and application in this and other countries where British geologists predominate.

After touching upon instrumental surveys advocated by geophysicists and eschewing these as unreliable, the author dwells upon the genetic relationship between coal and oil. The principle of fixed carbon ratios is directly evolved out of a proper understanding of the essential nature of this genetic relationship. The researches of Dr. David White led to the enunciation of this principle by him in 1915. Since then its application in the field was actively supported in America by numerous adherents and the results have been remarkably successful.

Geological conditions in the Indian Empire are quite favourable for this line of investigation of the Empire's oil regions. Structural study is only of additional importance. The Geological Survey should initiate this line of field investigation for the benefit of private workers and oil investors. The foot-hills of the Arakan range in the Pakokku district give us an ideal tract for this new method of surface investigation.

Private agencies work under great limitations and they cannot turn out reasonably good work in this direction at the present stage of development of the Empire resources.

16. Note on the Limestones of the North Arcot and Salem districts, Madras Presidency.—*By* M. VINAYAK RAO.

In the Archæan complex of South India there is a band of limestones extending several miles with other parallel bands. They form what is known as a sigmoid flexure. They are grey to bluish in colour and vary in texture from crystalline marbles to fine-grained limestones. From a microscopic examination of the slides, for which I am indebted to Mr. L. A. Narayana Iyer, they appear to be metamorphosed sediments. One of the limestones approximates to a calc granulite described by Dr. Fermor from the Chhindwara District, C.P.

The Mysore geologists consider that the Limestones in Mysore are probably not of sedimentary origin.

The Limestones are well exposed near Padavanur, about 2½ miles S. of Samalpatti station on the South Indian Railway.

A manganiferous limestone is seen near Sakarsanhalli 4 miles S.W. of Bisanattam station on the M. and S.M. Railway in Mysore territory. The Padavanur Limestones are probably of the same age as these, in which case they would represent some of the oldest members of the Dharwars.

17. A contribution to our knowledge of *Dadoxylon Arberi* Seward.—*By* B. SAHNI *and* T. C. N. SINGH.

Our knowledge of this Australian species is confined to the secondary wood (*Arber 1905 Glossopteris Flora p. 191 ; Seward Fossil Plants Vol. III. 1917 p. 255 ; Seward Vol. IV. 1919. p. 178.*) The pith and primary xylem, which are both important for diagnostic purposes, have not so far been described. The authors describe a specimen in which these parts are to some extent preserved.

The pith is cylindrical and wide but not discoid, thus resembling that of other Dadoxyla in floras of the southern (Gondwana) type, and differing from that of the typical Cordaiteae. The primary bundles project as salients into the pith and consist, partly at least, of scalariform tracheides; these latter graduate into the metaxylem tracheides with multiseriate hexagonal pits. *Locality*: Sugarloaf Range, New South Wales (Newcastle coal-field).

The specimen was kindly lent for investigation by the Director, Geological Survey of India.

18. The mechanism of intrusion and magmatic differentiation in Mount Girnar.—*By* K. K. MATHUR, V. S. DUBEY *and* N. L. SHARMA.

In a communication to the Indian Science Congress, 1925, an account of the rocks of the Girnar Hills was given as the result of a survey of the North-Western area. The work has been continued and the geological mapping of the hills has been completed. The distribution of rock types gives interesting information regarding the mechanism of intrusion and differentiation of rocks.

The intrusion forms a laccolith the base of which is not exposed. With regard to the mechanism of differentiation the agencies of assimilation and immiscibility are regarded as improbable, crystallization appears to be the principal process responsible for the differentiation of the magma. Field evidence has been noticed supporting the origin of nepheline-syenite by the dissociation of the polysilicate felspar as suggested by Bowen.

The uplift of the central part took place in two stages, a third phase of movement was marked by the intrusion of the residual granophyric magma in the outer hills. This feature has been explained as the result of a system of circular fractures developed at the time of the main intrusion. A radial system of fractures in the roof is also noticeable in the radial ridges sent out by the central mountain.

The physical conditions indicated are a high viscosity in the beginning and quiet crystallization with absence of convection and crystal-settling.

19. On the possible nature of underground Mica from surface indications of Pegmatites with reference to the Chooardih area of the Gaya Mica belt.—*By* K. K. Sen Gupta.

In this paper the author describes some mica deposits of the Chooardih area of the Gaya Mica belt. The pegmatites with sharp boundaries are uniform in texture, composition, and thickness rendering the calculation of the quantity of mica easy whereas the lenticles and segregation veins are more difficult to value as they are generally irregular in texture, composition, and thickness.

The mica occurs in tolerably large sheets of sizes Nos. 3 and 4 (10-14$\frac{7}{8}$, 6-9$\frac{7}{8}$ ") but is so cut up by partings and straight cracks that only size No. 6 (1-2$\frac{1}{2}$") could be recovered by trimming. The partings and 'V' structures are induced by the pressures to which the rocks in the neighbourhood were subjected. From the general shattered condition of the rocks and the constituent minerals it could safely be predicted that the mica of the pegmatites occurring underground would also share in the general shattering.

20. The extinct iron industry of the neighbourhood of Mount Popa, Upper Burma, with notes on the microscopic study of the slags.—*By* H. L. Chhibber.

Numerous iron-slag heaps and deserted furnaces were noted during investigations of the Geology of Mount Popa. They have been alluded to also in the writings of Theobald and Dr. E. H. Pascoe. As recorded by Bell legend connects the earliest history of the extinct smelting industry in Burma with Mount Popa. The ore used comprised hollow or solid ferruginous concretions in the Irrawaddy Series (late Tertiary). The concretions are irregular but roughly discoidal and vary in size from one inch to three inches, with occasional larger ones, up to eight inches in length. The concretions appear to be caused by rhythmic deposition around a clay or clay ironstone nucleus and the colloidal origin of these concretions is emphasized. Often there is a remarkable succession of concentric bands of haematite and limonite. The structure resembles that seen in oolitic and pisolitic grains but is on a much larger scale. Haematite is present both in the crystalline and amorphous forms, in addition to limonite and, probably hydrohaematite. Besides the above small quantities of psilomelane are also associated with the concretions as the presence of manganese in amorphous botryoidal form has been confirmed chemically.

The localisation of the concretions is probably due to the distribution of the clay nodules which serve as nuclei. The presence of silicified wood and curiously shaped calcareous and siliceous concretions in the Irrawaddian affords further evidence of the activity of various types of mineralising solution through the sands.

The extent of the iron smelting industry can be judged by the widespread occurrence of the slag heaps. The furnaces and simple methods of extraction are being described. No flux was employed and the fuel used was charcoal.

Microscopically, the slags are highly ferriferous and basic with a development of fayalite, babingtonite and fantastic growths of magnetite.

21. Some notes on the origin and mineralogical constitution of the late Tertiary fossil wood of Burma.—*By* H. L. CHHIBBER *and* L. DUDLEY STAMP.

W. Theobald was the first person to attempt a scientific explanation of the origin of the fossil wood which occurs in such enormous quantities in the Irrawaddian of Burma. He attributed its silicification to siliceous springs connected with volcanic activity—a theory already called into question by Noetling and Dr. Pascoe. The principal volcanic rocks of the Irrawaddian tracts—Kabwet, the Lower Chindwin and Mount Popa—are distinctly post-Irrawaddian. Moreover, xenoliths of the fossil wood caught up in the Mount Popa lavas and greatly altered have been found, and the action of volcanic waters in that locality has frequently changed the normal silicified wood into a beautiful white opal.

Mineralogically, the normal constituent of the wood is chalcedonic silica, with a tendency to pass into a microcrystalline condition. Occasionally the petrifying material is calcareous or ferruginous.

Fossil wood occurs at other horizons in the Tertiary of Burma. In the lower part of the Pondaung Sandstone wood is associated with marine fossils. All the wood has there been carbonised. Passing upwards in the Pondaung Sandstone conditions become more estuarine and finally freshwater or even aeolian, a change which is marked by the occurrence of silicified wood instead of carbonised. It seems quite definitely established that the silicified wood of Burma is associated always with fresh water or aeolian deposits. Silicification of wood is known to take place under desertic conditions, and it is suggested that circulating solutions depositing colloidal silica were responsible for the silicification in Burma. It may be necessary to postulate alternate drying and wetting of the wood during the process. Some of the wood certainly seems to have been dried before preservation as it exhibits the remarkable contortion of fibres often seen in dried logs of timber.

The character of the wood, unfortunately, does not afford conclusive evidence of the climate of Irrawaddian times. The bulk is dipterocarpous (including *Dipterocarpoxylon burmense*). Half the denizens of the wet, evergreen equatorial forests of Lower Burma at the present day are Dipterocarps but a Dipterocarp (*D. tuberculatus*) is equally characteristic of the driest forests of Burma. A large quantity of monocotyledonous wood also occurs, especially about the Pegu-Irrawaddian boundary. Some of it closely resembles the wood of the Toddy palm (*Borassus flabellifer*) a typical denizen of the Dry Belt of Burma, but this palm is a native of Africa. On the whole the evidence seems to point to the climate of the Irrawaddian being a dry one in Central Burma and it may be that the uprise of the Arakan Yomas at the close of the Peguan interrupted the rain-bearing monsoon winds and instituted the dry, rain-shadow area which persists to the present day.

22. Rhythmic banding of Ferric Oxide in Silicified Rhyolite Tuffs of Kyaukpadaung, Upper Burma.—*By* H. L. CHHIBBER.

Specimens of Rhyolite tuffs showing rhythmic banding were found amongst the partially silicified tuffs of Kyaukpadaung area, Myingyin

District, Upper Burma. The bands in one specimen are irregularly concentric, while in the other the bands are elliptical. In the former the bands are bright red in colour and the material forming the bands is haematite, the bulk of the rock is whitish in colour. In the other the bands are yellow in colour due to limonite resulting from hydration of haematite under atmospheric conditions. The mass of the rock is purple and the colour is due to the minute grains of haematite which are clearly visible under the microscope. The banded structure is due to ferruginous solutions acting contemporaneously with or subsequently to the silicification of tuffs, and appears to be a case of the so-called Liesegang rings. The microscope shows the rock to consist of crypto- or micro-crystalline silica. It has been shown by Holmes that gels are not necessary for the development of the rings as he has demonstrated their formation in loosely-packed flowers of sulphur. It is therefore possible that the fine-grained, fairly homogeneous tuff acted in the same way. The writer has already suggested a similar origin of the ferruginous rhythmic banding, so well seen in the Older Lavas described in the paper on the Igneous and associated rocks of the Kabwet area, Upper Burma, published in the Transactions of the Mining and Geological Institute of India. On the other hand the rhythmic deposition of iron may have taken place whilst the silica deposited in the tuffs remained in the colloidal condition and functioned as a gel.

23. A note on the rockslide at the Western-ghat Section, S. India.—*By* C. K. KRISHNASWAMY PILLAI *and* V. S. SWAMINATHAN.

I. *Introduction.*—The nature of landslides and rockslips, and their frequency of occurence in mountainous districts.

II. *Classification of landslides.*—

A. Movements involving detritus
  1. Soil-creep
  2. Earthslide
B. ,, ,, solid rock
  3. Rockslips
  4. Rockfalls.
C. Compound slips with respect to character and amount of material.
D. Unclassified and special cases.

III. *Detailed description of the occurrence.*—The area covered by the fallen debris was nearly 5000' by 1000,' and a complete dislocation of the traffic for nearly a month and a half was the result. The original Railway line had to be abandoned for some distance, as it was totally buried beneath a huge mass of débris.

IV. *Cause of the slide.*—The immediate cause of the slide was the heavy precipitation that preceded the occurrence. Other relevent causes are alluded to.

V. *Conclusion.*—The slide was not the result of a 'volcanic earthquake'. The tremors locally felt were rather the after-effects of the huge slide.

Section of Medical and Veterinary Research.

President :—R. Row, O.B.E., M.D. (Lond.), D.Sc. (Lond.).

Presidential Address.

ON THE PRESENT POSITION OF THE MEDICAL PROFESSION AND MEDICAL RESEARCH IN INDIA.

SISTER DELEGATES, BROTHER DELEGATES,
LADIES AND GENTLEMEN,

On behalf of this Section of Medical and Veterinary Research I have great pleasure to accord you a most cordial welcome to this beautiful city. Before proceeding further I have to express to you my heartiest gratitude for doing me the great honour of presiding at this Research Section. I am fully alive to my shortcomings and it is on this account that I felt hesitation in accepting this honour for which I have been approached for some years. But when Bombay was given the honour for the second time by the Science Congress meeting here, and when our last year's worthy president almost commanded me to this honour I felt it my duty to obey and I responded to its call, although I have always held that a private member of the profession unconnected with either a State hospital or Research Institution and at best an amateur at research has no business to undertake this responsibility and that the honour should always go by right to those better qualified and more favourably placed by their excellent work and long connection in the well-equipped Laboratories and Research Institutions, because they are on the one hand best fitted for undertaking research problems and are in direct touch with the profession in general both here as well as abroad, on the other. However one or two considerations, apart from the call of duty, have led me to this honoured seat. First, I thought that this Section perhaps would feel interested to have the views in connection with Medical Research from a private member of the profession, and his independent observations on the present state of our research and its relations and direct bearings on the practical side of Medicine, as is applicable to both the Clinician and Sanitarian. Secondly, Bombay has a special claim on me, where most of my active life has been spent for the last 35 years, both as a Medical Student, as a Physician, and as one interesting himself with a variety of problems, however insignificant, having some bearing on research. I may also remind you that Bombay owes a deep debt to research because it is here that the earliest observations in Scientific Medicine of the West were first inaugurated, by no less a person than Henry Vandyke Carter, of revered memory—an individual of rare attainments and a star of exceptional brilliance of the Indian Medical Service to which he belonged, and one of no less lustre of the Medical world at large. It is here, I say, Henry Vandyke Carter made his epoch-making investigations on a variety of subjects, under most difficult and unfavourable circumstances, of which his work on the Relapsing Fever and Mycetom are classics in our medical literature. Then after a comparative lull which often follows the advent of a great luminary, it was to Bombay that many eminent men of Medical Science were attracted by the urgent demands created by the advent of the First Plague Epidemic in 1896 and onwards.

It is again in Bombay that several most important truths on the epidemiology and pathology of the disease were brought to light, of which the most remarkable result was the elaboration of the Plague Prophylactic Vaccine by W. M. Haffkine, which up till this day it has not been possible to improve in any marked degree, in spite of several efforts directed towards that object. And lastly I may be permitted to remind you that it is here that the important role played by the rat-flea, in connection with plague, was scientifically worked out under the most dangerous conditions by the Royal Society's Plague Investigation Committee, under the masterful direction of C. J. Martin of Lister Institute, in association with an indefatigable band of great workers. This band consisted of not only eminent colleagues of the Director from the Lister Institute, but also of a picked body of exceptional merit from the Indian Medical Service, and also some co-opted members of the local medical profession in which even the humble sub-assistant surgeons played their noble part. Finally, it is here that several scientific activities are being carried on by a large body of medical research workers of proved merit in the Bombay Bacteriological Laboratory, now fittingly called the Haffkine Institute, where you will have an opportunity of seeing for yourselves the wonderful things the able Director, my friend Major Morison, has been kind enough to keep in store for us.

My very able predecessors have fully dealt with, year after year, the important and pressing problems bearing on disease and its prevention. They have referred in detail to matters connected with epidemics and endemic diseases. They have also discussed the importance of dealing with these problems in the field and have shown us the various ways and means of doing so. The value of studying etiological factors and the role of insects in the propagation of disease have also been ably pressed before you. I do not propose to deal with any of these subjects important as they are. I feel I should content myself in endeavouring to place before you some reflections on the present position of the Medical Profession and of Medical

Research in India in the hope that you may take them as worthy of your most earnest consideration, as I feel convinced that they are vital not only to our future interests but to our very existence. But before doing so I may be allowed to review in broad outline the composition of the profession as it is in England, with some reference to its relation to its research section, in order that we may be better able to see how we stand by comparison. The senior members of the profession and those connected with Research Institutions are, I am sure, familiar with the conditions which exist in England, but I am persuaded to refer to them here, having in my mind the younger members of the profession, to whom these considerations are submitted in the form of an appeal.

Our profession in England is now an organisation of strong growth built up by many generations, with a long and honourable tradition and noble associations, nurtured and slowly strengthened by knowledge acquired by long experience and wonderful experimental and scientific achievements, from which it now draws its life-blood. It is composed partly of masters of great professional eminence and recognised scientific reputation, but chiefly of a large body of professional men educated in the best Medical Schools, all of whom form one solid national institution, which the whole community counts as one of its proudest and most cherished assets. For my purpose the organisation may be described as being made up of two main sections, the functions of which it is important to differentiate, so as to be able to appreciate how one section is related to the other, and how by a proper co-ordination of functions of both the community and profession itself have been best served. One section is that which is associated with the practice of medicine by its being directly concerned with the alleviation or relief of suffering, or cure and prevention of disease by the application of scientific knowledge and long acquired experience, and therefore one with which the public is more familiar; the other section is that which, though hardly of interest to the lay public, consists of workers behind scenes—the Scientific or Research workers in the realms of physiology, biology, pathology, etc., who are concerned with problems of far-reaching interest, yet none the less important, for the benefit of the general application by the individual members of the section, viz., that commonly styled the Doctor Class. In the growth of any institution it is needless to remind you of the importance of the interdependence of these two sections, the more so in Medicine where, but for the triumphs of the scientific side and the direct application of these to the general utility of the public, our profession would have been in that not particularly enviable state whose descriptions as read in the history of early Medicine are a source more of amusement to us than of instruction. The scientific section concerns itself with the progressive extension of those facts acquired by continuous observation and experiment, and made available massively and individually to the practitioner. The masters in these two sections know how to appreciate each other's contribution towards the general advancement of the profession, and even those of the juniors who branch off to the clinical side are in a position to rightly estimate the role played by those who have chosen to continue their devotion to science, as no clinician worthy of the name can aspire to maintain his position except by the benefit of a close association with the expanding knowledge contributed by his scientific colleague. The one branch is as important as the other, and the combined output of effort and its vast advantages which the intelligent British public have learnt to appreciate has put a large number of Research Institutions in England and Scotland on as permanent a pedestal as the more popularly recognised institutions—the hospitals, infirmaries and cliniques—that one can safely say that both these activities have now come to stay and form a part and parcel of the national organisation; and with the unlimited resources of England's wealth, light and leading, individually and collectively, there is no fear or anxiety for the future further development of the present profession.

And what do we find here? The medical profession, if we may so call it, is hardly of a few years' growth. It consists of a heterogeneous mass of members who are unfortunately marked off into water-tight compartments. Perhaps it is in the natural course of things that this sort of caste system prevailing in the country should permeate the very roots of every institution planted here, however important and catholic, even perhaps with more rigid restrictions.

We have in the first place a small number belonging to the superior services, consisting chiefly of the members of the Indian Medical Service transferred to the civil side, and a large body of two distinct classes of the subordinate service, one belonging to the Assistant Surgeon Class, drawn from the University Graduates, and a much larger section, that of the sub-assistant surgeon class, trained in the Medical Schools; and lastly a very large body of private medical practitioners drawn from the last two categories. Then again we have an official side and a non-official side, with various grades, and each with its own vested interests. Then we have a huge mass of uneducated and inappreciative humanity whom we are called upon to serve, without the basis of one common interest and ideal such as guides the profession and the public in England. Now, in spite of all the strenuous and most earnest efforts on the part of the senior members of the official as well as non-official section, in the face of the existing distinctions above described, I leave you to form your own conclusions as to the possibility of forming any corporate organisation worthy of the name even for many years to come, and all this in the midst of a conflict of classes and individuals, each striving to push his own interest, in which jealousies arising out of seniority as opposed to efficiency play no small part, especially in the higher professional, scientific and specialist departments. Further in a few important cities we have a small body of men, who having the advantage of broader education and wider travel abroad, have returned home with an earnest desire to co-operate to form a profession, claiming as they do a professional equality with the members of the senior services. Even here with all earnestness and enthusiasm, in the very nature of things and under the peculiarly hard conditions under which they have to work—there are already unmistakable signs of want of cohesion and comraderie.

On further examination, leaving aside for the moment the members of the superior services whose loyalty to the mother profession rightly comes before everything else, even before their own service interests, whose well-established and noble traditions any service may well be proud of, leaving aside also those graduates who are drafted into government departments for specific purposes, all that is left to the profession in India are the private practitioners. These, if they are at all inclined for post-graduate work, spend all their energies towards acquiring those qualities which would make them more efficient clinicians; without any desire to belittle this inclination it is painfully clear that they do not seem to recognise the very existence of the other side of the profession, much less to appreciate its importance, perhaps because of their not having had any chance of coming into contact with any living examples in their teachers, who are themselves concerned with nothing beyond the practical side of the profession.

Even out of those who go abroad in search of higher education, and who would naturally be expected to be brought under the influence of great masters in Medicine, we find very few indeed who interest themselves in scientific work. All alike seem to be drawn towards the acquisition of attractive and high-sounding diplomas and degrees, which unfortunately ensure to them a very lucrative private practice soon after their return to this country. That is perhaps why in large cities like Bombay we can boast of a fair number of these highly qualified men actively engaged in different branches of practice, and to me, being one of them, it is a matter of no small pride to see them keeping themselves above the waterline in the face of keen competition. It would, however, have given me greater joy to see some of them at least devote a small portion of the day to pursuits not directly connected with the practice but to the scientific aspect of the profession, even for their own edification, and give better account of the valuable clinical material which would be abundantly at their disposal. But the scientific atmosphere does not exist, and it is to be feared that if this tendency continues we shall have a repetition of the same cycle. There are however some considerations that may explain this. The careers for men who may be induced to take up scientific pursuits are extremely limited; and as I have stated above, even in England it is only the love for the scientific and educational branches of the profession, inspired perhaps by the noble spirit of selflessness under the rare stimulus of working under great masters that attracts a few workers in this field, but such opportunities are still fewer in India on account of the extremely limited number of medical schools on the one hand and complete absence of any Research Institutes open to them on the other. The situation is in no way improved by the peculiar attitude taken up by the clinician towards his scientific colleague, whose silent labours he is only ever ready to exploit, without even a thought of giving anything in return. The clinician further assumes an air of superiority by virtue of his being placed in more intimate and favourable relationship with the public with whom the very nature of his practice brings him into closer contact.

As to the attitude of the general public towards the profession, the less said the better. In Bombay we are extremely fortunate and proud to possess a good few individual philanthropists who have given generously to the founding of Medical and Science Institutions. The absence however of a single general hospital throughout India founded, run and administered by voluntary contribution by the general public, is its own commentary. Even in matters of urgent medical relief it is only an earnest appeal from a kind-hearted governor like our distinguished patron that seems to awaken for the time being the public conscience of the wealthy classes to their sense of duty towards the less fortunate poor. Therefore to think of interesting the general mass of the public to appreciate the finer shades and different functions of the various branches of the profession and their comparative importance in the growth of medical science is hopeless and out of the question. Even the more educated and enlightened members of our community have no ideas regarding the functions or the finer attributes of the medical profession. To them the medical profession simply does not exist; except for the purpose of affording immediate relief of personal suffering, such as the cure of a disease or a surgical operation and that too only when the urgent necessity is brought home to them or to members of their families.

We have only to remember in this connection one or two matters of recent occurrence by way of illustration. The cruel blow that was dealt to the late lamented project for a Tropical School of Medicine for Bombay, which is illustrative of the unconcern of even the powers that be, of Sir (now Baron) George Lloyd's regime, is too fresh to be easily forgotten. Perhaps it is in keeping with the spirit of contempt for the man of science and the expert with which government departments even in England are imbued. It would take us too far to go into the details of this sad episode. But I felt that the Research Section should know how the Tropical School Scheme (which, if materialised, would have created for us a new atmosphere and for which it was essentially conceived with the rare munificence by one of our foremost philanthropists (Sir Dorab Tata) was throttled after a strenuous and painful labour of over 12 years just as it was on the point of coming into existence in 1921, even after the arrival in Bombay of one of the Tata Professors urgently selected for this purpose by the Royal Society at the special request of the Government of India. And thus was thrown away a magnificent endowment of over 25 lakhs of rupees because the then Government of Bombay would not do even a portion of their part of the contract (for further information *cf.* four voluminous files, Educational Department, Tata's, Bombay). As a second illustration of the apathy of the enlightened public to medical research, I have to refer you to the short para. (155) in the report of the Bombay University Reform Committee in which this learned body have disposed of this all important subject showing us in unmistakable terms their conception of Medical Research (*vide* page 132 of the Report).

It may be convenient now to review the position Medical Research in India. We have five or six Government research institutes scattered over the country under the direction of, and staffed practically by, the splendid officers specially selected from the Indian Medical Service. In spite of their isolation, from any centres of clinical activity or teaching, the institutions have been very successful in carrying out government requirements, such as anti-rabic treatment, preparation and manufacture of prophylactic vaccines curative sera, etc. Further a few other problems of scientific interest are undertaken by some members of the staff individually when they are inclined and under government orders. And it is a matter of no small satisfaction to find, in the face of many difficulties, the record of these research workers as seen from the published reports in the Indian Journal of Medical Research. These records speak for themselves. One would have been contented if the present activity and further development in this direction, could be assured. But there are ominous indications of Government's difficulty in finding men to direct and staff these institutions, even to maintain the present standard of efficiency. These fears are based not on imaginary alarm but from what we actually see in the authorities finding enormous difficulty in supplying the personnel of even existing educational institutions. Those of us in Bombay interested in Medical education having anticipated those difficulties, had put forward before the Islington Commission in 1913, when as their mouthpiece I had foreshadowed the coming dangers, a few suggestions with a view to be allowed to associate ourselves with the medical education of this city, so as to be able to relieve to a certain extent the enormous strain under which the educational staffs were working at the time. But none of us expected that within 10 years we thould be brought to face the present predicament. Some of shese suggestions had to be given practical effect to, not through any recommendation of the Islington Commission nor by any gesture from the Indian Medical Service, but by the stern necessity created by the War, when under a danger common to us all, some of us availed ourselves of the opportunity of associating and co-operating with our colleagues of the I.M.S. To me it was a great hope of a unique augury of establishing of a more cordial relation, a better *modus vivendi* and a mutual confidence and a better understanding with each other. But this, alas, does not seem likely to be realised for a long time to come owing to a variety of circumstances created after the War, political, economic, etc., and the result has been the complete dissatisfaction in the I.M.S. itself, the immediate outcome of which is the danger I have referred to.

This leads me to take a short rèsumé of the present situation created by the I.M.S. Some of you, my friends in the Service, are surely better acquainted with this subject than myself, and I have with me some broad statement through the kindness of one of my friends.

“STATEMENT.”

1. “By reduction of the number of billets in which a man might save a modest competence in the last few years of his service the service ceases to be attractive to men of the former higher standard that formed the I.M.S.

“What man is going to face 14 years' penury in a tropical country with all its risks to the health of himself and his family when he knows there is no certain prospect of obtaining any billet worth having after his fifteenth year of service ? The service thus loses suitable men for the military cadre for ordinary work. (2) On war reserve of expert specialists trained in military needs. (3) Teachers for training centres and administration of the same. (4) The occasionally rarely found man capable of research in eastern diseases.

2. “The attitude of non-service medical men towards men in the I.M.S. is in the main one of veiled jealousy. A professional boycott in the main characterises the relationship of the leaders of non-service members of the profession towards the few remaining service men at the head of this service.

3. “In teaching centres discipline is difficult to maintain

because of the subtle and systematic exploitation of ill-trained and illiterate students by junior members of the staff whose delight it is to undermine disciplinary control by the I.M.S. staff under the veil of political expedient. The result is that the students take into themselves powers to make themselves objectionable to any one who attempts to maintain western standard of efficiency. Administrative posts are now billets to be avoided and they can only be filled with the greatest difficulty.

4. "Those who have any experience of these fields in India will probably agree with me in the following criticism:—

(*a*) Research work is dead outside a few members of the I.M.S. and still fewer in non-service men. The laboratories of India turn out no longer new ideas, they are mere bottling centres for standard vaccines and sera.

(*b*) The standard of teaching and training in western medicine is rapidly falling. The students are too illiterate to understand what they are taught; the teachers too inexperienced in teaching to be able to train men in the early stages of their professional teaching. This is best seen in the out-patient's departments of great hospitals.

(*c*) Examinations are no longer run on honest lines. Selection of examiners, their methods of examination of candidates, the system of exemptions and grace marks are too often near the border line of fraud to be satisfactory."

However it has devolved on me to note the impressions generally understood by those outside the Service. It is believed that recruitment to this service having of late become very difficult one cannot hope to have any replacement of those officers who are rapidly disappearing. And entrance into this Service which was always considered a great prize and therefore attracted some of the best talent from all the famous medical schools in England, Scotland and Ireland has become suddenly very unpopular with the sad result that many of our institutions which always depended on this inexhaustible store are already showing signs of feeling the strain of the depletion. What has brought about this misfortune I am not competent to deal with. Nor am I in a position to deal with by what means confidence can be restored. All we are faced with is the grave fact, and one cannot feel the situation too keenly as it would be worse than ingratitude if we did not do so, as it is to this very glorious service that the present medical profession owes its very existence from its birth and during its growth. It is the I.M.S. who founded the medical colleges and directed the medical education of this country having always given it its best; and it is but natural that when we are threatened with its disappearance that we shall realise more than anybody else that our present as well as our future, which has been bound up so intimately with its prosperity, is also threatened to share the same fate.

Such are the considerations of our present position, and the story is as depressing for you to hear as it is distressing for me to relate. With the withdrawal of the superior service from its present activity, I for one feel diffident that we, as we are at present constituted if called upon to take up that activity, shall be able to shoulder such a heavy responsibility both on the educational and research sides unless we get the benefit of a substitute service of not only equal accomplishments and versatility and distinction, but based on much broader and cosmopolitan policy of selection purely with a view to efficiency and without prejudice and animated with even much higher ideals such as would ensure a product of its own creation, who would be worthy of taking upon themselves its responsibility when such a time would arrive in future so as to keep up the continuity of its own usefulness.

This leads us to the subject of reconstruction with a view not so much to supply our immediate wants as with an eye for even a distant future, and may be considered under two main heading, *viz.*, (*a*) Educational and (*b*) Research.

It is not my purpose to deal with (*a*) except in so far that it has a direct bearing on (*b*) which, stated in brief, is the urgent necessity of having a research unit as part and parcel of every medical college so as to prepare the feeding ground for future workers as they have in the Tropical School in Calcutta. Before going further, it is perhaps as well to bear in mind some salient and well-established truths with regard to research—truths such as you are familiar with.

Research is a means to accumulate knowledge, and any result which may be brought to light in the course of this is acquired slowly and laboriously without any spectacular effect—except in rare instances; and it is only when a sensational announcement as to the practical application of such a result is made that the public is awakened by the news that someone has been working somewhere on something. What Huxley described as to the value of physiological knowledge is perhaps equally true of research. Research then has its own value and it is as absurd to bind it down by official rules as to attempt to control it by time or space limits, however important and urgent the solution of a problem may be. Yet we have certain conditions which are essential for its healthy development. These are in three words, *Material, Money, and Men;* all three of which are equally important. In some countries one or other of these is difficult to obtain and that is why it does not thrive there. And we might examine how we stand:—

MATERIAL.

India is a country which offers peculiar attractions to workers all over the world, and on account of a fairly well-organised medical machinery all over the country India affords unique facilities for any investigation. It is notorious that problems which are unexplored or not fully worked out are abundant. Your notice has been drawn time after time to the appalling death-rate caused by one disease or the other. The frightful state of mortality during any kind of epidemic is one which would stagger even the casual observer. There is no country where the returns from the Public Health Commissioner's report year after year are so depressing and heart-rending. As was pointed out by my learned predecessor last year, deaths in British India from Fever alone during 1922 claimed no less than 8½ millions and 2 millions from Cholera. Those from Plague during the last 20 years are calculated at over 10 millions. Apart from this frightful toll of deaths from disease or other equally sad epidemics the amount of incapacity and loss of energy caused by incidence of disease and the consequent economic loss can well be appreciated when we take into consideration the admitted fact based on calculation that the incidence of Malaria alone claims no less than 100 million victims of the population every year. Some of the diseases peculiar to India have baffled the investigator. I refer only to Malaria and Diarrhœas, Anæmias, Kala-azar and Leishmaniasis. And the problems set up by Tubercle and Leprosy even from the endemiological standpoint are so deep that they will fully occupy teams of workers for several years.

MONEY.

No undertaking requires the aid of funds so much as Research as the allotted grant disappears rapidly before any results are available. The Funds required are first: to provide for (1) at least a living wage to the workers; (2) the enormous cost of equipment; (3) current expenses and contingencies which one cannot often foresee; (4) in addition one has to provide for field work and fitting up expeditions for special enquiries, etc. In India most of the research laboratories being Government institutes, they are well provided for with equipment and staffed by Government officers of distinction from the I.M.S., to which are occasionally drafted men from outside. It must be admitted that the Government have been very liberal and have given freely considering their general attitude towards medical and sanitary matters. We have in addition an organisation called the Indian Research Fund Association happily inaugurated by the foresight and influence of the late lamented Sir Pardey Lukis, the then Director-General of the I.M.S. It has a very influential governing body and a strong scientific advisory board. Their assets, it may be noted from their recent reports, amount to investments of the face value of over 52 lacs of rupees, and they have been able to advance to the extent of Rs. 15,81,000 and odd in 1921, Rs. 9,10,000 and odd in 1923 and Rs. 4,56,000 and odd in 1924 in the interests of research. This grant has helped investigation in a variety of subjects by a large number of I.M.S. officers who have been set to solve a variety of problems pertaining to disease and public health. It has also enabled the appointment of some non-I.M.S officers, though only 8 since 1914, who have been associated with the regular staffs. Thus we have in this Research Fund a solid nucleus which is capable of expansion with the help of appeal from high quarters to distinguished and rich public-spirited princes and enlightened people, and its utility enlarged, especially, if the Fund is guarded carefully as a solemn trust for the sole purpose of advancing research and utilised only to find a living wage for such qualified workers who have no other means of support and not spent away in adding to the allowances of highly paid officers who are attached to these institutes. For after all the advantages and the opportunities that such paid officers would derive in the course of their investigations by being attached to such institutions should be in themselves an incentive to the workers if they are scientifically inclined or experienced in research, so that the utility of the Fund may be applied to wider fields wherefrom men of ability and distinction may be attracted to join; and with a certain amount of tact and liberal policy the best talent available in the country may be induced to take up a scientific career.

Then we have to bear in mind the generous support Research in India has in recent years received from the Rockefeller Foundation. And already some selected officers have come under its benefit, and after the requisite training some of them have even returned to India. How these men of such excellent training are utilised to the best advantage by Government is more than I can tell. The usefulness of these scholarships cannot be overestimated; as the selected men are brought in direct touch with the most recent advances in the technique and organisation in the best known Research Institutes of Europe and America and trained with a view to give the benefits of such a training after their return to this country. Perhaps greater care and more rigid tests may be employed in the selection of young and promising workers and the benefits of this generous support made better known and more available to a larger field by offering an open competition to the best available candidates, and not being given away as favours to some fortunate officers already in Government employ and as rewards to men for their services in the subordinate departments. Further it may be suggested that if Government could assure a suitable employment of such highly trained men on their return by instituting a Superior Medical Research Service, it is sure to act as an incentive to a much larger body of young men of promise to take to a scientific career: And this would gratify no one more than the Rockefeller Trustees themselves who will see that their money spent in training us has been fully utilised and it might even induce them to extend to us further support.

Here I may quote from the Rockefeller Foundation Review for 1922, "The fellowship policy of the Foundation aims at flexibility, selection and specific preparation. No fixed number of fellowships is assigned to any one subject or country. Only candidates of exceptional promise to whom positions in the Government or institutional service have been assured on the completion of their studies." In this connection you will be interested to know that in 1922 no less than 237 fellowship holders—from 27 different countries of the world including one from Ceylon—were appointed to come under its benefit. Under these circumstances I feel it is of utmost importance, unless we deliberately choose to lose the advantage of this foundation, to impress the urgency of moving the Government of India, to extend to the Trustees of the Rockefeller Foundation, the courtesy of an invitation to visit our country's educational centres and Research Institutes, with a view of having the benefit of their report on the present situation and of such suggestions as may be of value to the Government of India in the best interests of Medical education and research.

MEN.

From the above it will be seen that we have abundance of material and it is just possible to raise enough money required for the present purposes of research. But when we come to consider the third essential, *viz.*, men, the subject assumes the most difficult aspect as it is not within anybody's power to create a suitable personnel; under the conditions in which we are labouring it seems we shall have to content ourselves with what we have at present and fit up expeditions and import expert advice at whatever cost as the urgency of the problems may demand. In all educational scientific centres in Europe, Research institutions are founded in honour of, out of compliment to, and after the advent of some personality whose lasting work itself entitles him to such a foundation. But out here it is the invariable rule to have excellent laboratories and first class equipment before the men fit to work in them are available. Our problems are vast and if they are to be worked out successfully they must be worked out on the spot by men equipped with the best training available here as well as abroad and fully competent to deal with the variety of causes and local conditions which themselves create the problems. But under the present circumstances, on account of the scarcity of workers, we have always to depend on knowledge imported from Europe or America, or make an effort to solve them as best as we can with what best the Government can spare for us out of their own officers; and it is to be feared when large funds are not available this arrangement becomes clogged after a time. Whether the country aims at autonomy, or Heteronomy or any other nomy, so long as we claim equality with the civilised and progressive nations, it is incumbent on us, for the sheer maintenance of our national prestige and good international relations to have not only a well organised profession worthy of the name, but also a machinery to ensure a continuous product of a body of men capable of undertaking the solution of the scientific problems of the country by themselves.

This takes us back to the subject of a thorough reorganisation of our medical colleges with staffs, at first, gathered from a wider field of selection, but ultimately recruited from amongst the best men turned out with rigid restriction as to private practice. Perhaps we might have models like those found in Britain or France, such as Research Institutes like the Pasteur Institute or ths well-known Cliniques, wherein large batches of men, in different departments under renowned Directors, immure themselves like monks in a Monastery, and work with a set purpose for several years under almost a starvation wage to acquire that perfection by severe training and hard discipline before they emerge out as members of the profession which is so rightly honoured and respected by the whole community. And lastly it is perhaps as well to remember that all who enter the profession should do so with a missionary spirit and with the conviction that it is a Profession of Sacrifice and Service where one must be contented, as a rule, with not very much more than the bare living wage and look to any little good that one might be fortunate to achieve as one's best reward.

Abstracts of Papers.

1. Experiments to determine the possible role of fruit in the spread of Cholera and the steps necessary to disinfect contaminated fruit.—*By* A. H. BUTT.

A few experiments were conducted in the Bureau to determine whether Cholera infection acquired by fruits, in vegetable beds or after washing at wells or shops with infected water, could enter the body of the fruit, or whether it remained on the outside of the skin only, and also whether washing with water, boiling water, or soaking for 1 hour in potassium permanganate (1 in 1,000) would disinfect the fruits. Fruits being of two kinds, those that grow on the trees and those that grow on the vegetable beds acquire infection either by washing with infected water or by watering from wells and manuring by sullage and to a limited extent by legs of infected flies.

It was tried to obtain the same conditions during these experiments as help to infect fruits with Cholera during the cholera season. A culture of Cholera Vibrio was obtained from Kasauli and a sub-culture 24 hours old was always used. This sub-culture was subsequently tested by Cholera red reaction and agglutination with high titre cholera serum, 1 in 2,000. After infecting 4 fruits by immersion in a dilution of subculture three were washed with ordinary water and hot water for 5 minutes each and immersed in Potassium permanganate solution (1 in 1,000) for 1 hour, while the 4th fruit was left untreated.

Pieces from various sides of these fruits were inoculated in Dunham's peptone and incubated for 24 hours and tested for the presence and absence of Cholera Vibrio. For control the skin of the 4th untreated fruit was also introduced into another Dunham's tube.

Experiments were performed with 6 varieties of fruits, results of which are embodied in a table.

Although experiments are insufficient in number to form final conclusions it would appear—

1. that infection is retained by the fruits on the skin.
2. Washing with ordinary water is not a reliable method for disinfecting contaminated fruit.
3. Washing with boiling water is safe in most cases; but it is necessary that the stalk end should be washed very thoroughly.
4. Infection does not penetrate beneath the skin of fruits except when the skin is soft and tender or when the fruit is over-ripe.
5. Immersion in Potassium permanganate (1 in 1,000) for 1 hour is not sufficient to disinfect it.
6. That the stalk end being the most difficult to sterilize, it is advisable to discard this portion.

2. The relative suitability of certain food stuffs as media for the cultivation of *V. choleræ* with special reference to their relative role in the dissemination of cholera.—*By* R. B. LAL, and M. YACOB.

Sterilized saline solution (0·86 %. pH 7) prepared in distilled water was taken as the standard medium with which other substances were compared. 9·75 c.c. of the saline solution was taken in a series of 10 test tubes and inoculated with 0·25 c.c. of a number of dilutions *viz.*, 100 % (i.e. emulsion matching No. 10 Brown's opacity tube) 50 %, 25 %, 10 %, 1 %, 0·1 % 0·01 %, 0·001 %, 0·0001 % of a young cholera emulsion prepared in distilled water. One tube containing 9·75 c.c. of the saline solution and 0·25 c.c. of sterilized distilled water instead of cholera emulsion was used as a control. Two grammes of solid substance or 2 c.c. of liquid articles to be compared were put in a similar series of test tubes steamed for 20 minutes, and inoculated with the above mentioned dilutions of the culture as in the case of the saline solution. Two additional tubes of these substances were kept unsterilized and inoculated from 10 % and 1 % bacterial emulsions. A control tube of the substance without the culture was also put up. The contents of these tubes were mixed well by means of sterilized glass rods and placed in the incubator at 37° C for two hours, after which period sterilized distilled water was added to each tube to make up to 10 c.c. The contents were again well mixed by means of the stirrers. One c.c. from each of these tubes was inoculated into a series of tubes containing 10 c.c. of Dunham's solution. Esch's medium was also inoculated with 100 % to ·1 % dilution of cholera emulsion, and also from the control. After 48 hours the number of positive cholera colonies as determined by their appearances and agglutination test was recorded, and cholera red reaction was performed in the peptone tubes by the addition of $\frac{1}{2}$ c.c. of pure sulphuric acid to each tube. The results were compared with the saline. Marked differences were observed and an attempt is being made to prepare the cholera culture index for the common articles of diet. Briefly stated the substances examined so far could be placed in the following four groups viz :—

1. Those which favour the growth of V. choleræ more than the saline solution.
2. Those which are equal to saline in this respect.
3. Those which let the bacteria grow, but less than the saline.
4. Those in which the cholera vibrio was not detected.

Group I *growth more than saline:*—Milk, Cooked Dal (mong), Boiled Rice, *Jalebi, Halva,* Gulab-Jaman (Indian sweets), Indian Oven baked bread, Unrefined cane-sugar, Puri, Fried fish, Pakaura, Green chillies, Split grain, Dal-mash, Starch jelly, Fried bread, Kabab-seekh.

Group II *growth equal to saline :*—Loaf of bread, Pera (Indian sweets). Chapatti, Mathi (Indian-biscuit), Khatai, Sugar, Veg. Curry (Pumkin) Veg. Curry (Brinjals) Onion.

Group III *growth less than saline :*—Balu-shahi (Indian sweet), Patisa, and Rasgulla (Indian sweets).

Group IV *no growth :*—Dahi (Curds), Sweet murmurra (Indian sweet), Syrup of Orange, Syrup of Nilophar, Syrup of Santal, Kulcha (Indian loaf of bread) Pickled lemon, Pickled mangoes, Jam-Gajar, Jam-Aola, Jam Harar and Jam Mangoes.

3. A population growth curve as applied to Madras.—*By* A. J. RUSSELL.

In a series of papers issued since 1920 from the Department of Biometrics, School of Hygiene, John Hopkin's University, Professors Pearl and Reed have shown that the growth of human population and the population from lower organisms grow under controlled laboratory conditions as described by the general curve of

$$Y=\frac{K}{1+me+a_1x+a_2x^2+a_3x^3} \;\ldots\; a_nx^n \ldots\ldots\ldots\ldots\ldots \text{(i)}$$

This was derived from a series of postulates (1) that the area upon which the population grows must be taken as a finite one with definite limits, (2) if there is a finite limit to the area upon which populations grow then there must be a finite upper limit to population itself. Pearl and Reed's papers give examples in which this curve fits population growths in a number of European and other countries from which census figures are available over a number of decades and they conclude that by its instrumentality they can describe a population's growth and can predict its future growth.

A simpler form of equation may be written thus

$$Y = \frac{b}{e^{-ax} + c} \qquad \text{......................(ii)}$$

where a, b and c are positive constants, and y is the population of the area at year x.

A priori we would infer that with India under present conditions the saturation point is not far distant. There is reason for supposing that India and China are now over-populated. The curve fitted by the method of the least squares to the six recorded census figures for Madras Presidency is shown in Graph II. *A priori* inference is not far from actual facts. The population from Madras Presidency is thus within 1–1¼ millions of the asymptote of this curve. It seems impossible for the population of Madras Presidency to go much beyond 43·6 millions.

During the last few years considerable quantities of rice have been imported to meet the needs of the population, but within a very easily measurable period of time this will be no longer possible as the populations of the food exporting countries are increasing so rapidly that within a few years no surplus will be available. Faced by these facts one is compelled to ask if the public health activities of this country are being developed on correct lines. What preventive measures are best suited to conditions in India when immediately a population expands above the upper asymptote there must occur some violent upheaval such as a severe epidemic or famine in order that the numbers may be brought within the limits demanded by the inexorable pressure of our equation.

Vast improvements in public health are urgently required, but these will not produce the most desirable results until the people of India recognise that a birth rate of between 40 and 50 per mille must necessarily be accompanied by an enormously high death rate and that very urgent reasons already exist for some restriction of population. In 1924 the Brahmin birth-rate in Madras City was only half that of the other divisions of the Hindu community; this section has apparently already realised the necessity. Comparing the two cities of Madras and Madura the growth curve indicates that the maximum population of Madras is within measurable distance, whilst in Madura a very considerable increase is still to be anticipated. Town Planning Committees and Improvement Trusts might advantageously make use of the forecasts made by extrapolation of this curve fitted to recorded census figures.

4. Some experiments with "Alastrim" Virus.—*By* D. A. TURKHUD *and* C. G. PANDIT.

5. Variation (?) in Vaccinia Virus.—*By* D. A. TURKHUD *and* C. G. PANDIT.

6. A progress report on an investigation into Filariasis at Puri (seventh paper).—*By* P. N. DAS *and* S. C. BASU.

I. *Morphology of adult Canine Filaria.*

Diro-Filaria—Probably Diro-Filaria Repens.

Male .. Length=5 to 75 c.m.
Breadth=1 to 20 m.m.
Anterior extremity—tapering and rounded—mouth with 4 Papillae.

Cuticle—No bosses Two unequal speculae near the anus.
Anus = ·035 m.m. from the posterior extremity.
Tail end is spiral. Three preanal papillae, one post-anal papilla but not voluminous. Papillae are triangular in shape.

Female .. Length—12 to ·17 c.m.
Breadth—·15 to ·38 m.m.
Anterior extremity—tapering and blunt.
Mouth 4 papillae.
Posterior extremity—round and blunt.
Uterus—2 coiled tubes near the anterior extremity.
Vagina—near the anterior extremity.
Anus—terminal.

II. *Experimented treatment of Canine Filariasis.*

Iodine, (1) Intravenously, (2) Hypodermically.

(1) 24·5 c.c. of 1% solution of Iodine intravenously from 25-3-25 to 7-4-25 failed to reduce the number of M.F. in blood and had no effect upon the adult parasites in the subcutaneous tissues.

(2) The subcutaneous tissue of filariated dogs at Puri is found at autopsy teeming with adult male and female filarial parasites.

Subcutaneous injection of iodine in different areas over the body of the dogs was seen to be followed by encapsulation of the killed adult parasites and in areas not reached by the iodine living adult parasites were found. Iodine subcutaneously had no effect upon Canine Micro-filariasis.

III. *So-called hereditary transmission of Filariasis.*

M. F. found in the blood of the foetus of pregnant bitches which harboured M. F. (Galep, Pourquie, Jemsen). M. F. found by us in C. S. fluid in Canine Filariasis. Out of 18 placenta examined M. F. were found by us in placental blood and the vessels of umbilical cord in one of the 6 women out of 18, who harboured M. F. in their blood. No M. F. found in the new born children or infants so far.

Placenta is known to filter off protozoal bodies.

Passage of M. F. through epithelial barrier of chorionic vili is possible. Katagwai's Observation (Japan Medical World). No passage of adult Filarial parasites through the medium of the placenta is known or appears possible.

No true hereditary transmission.

IV. *Experimental treatment of human Micro-filariasis* and *Elephantiasis by Stibosan* (Von Heyden's 471–31% Antimony).

Case No. I. Lymphangitis of Scrotum and Filarial Fever. Number of M. F. before treatment = 91 to 103.

After 8 Intravenous injections of 25½ grains of Stibosan from 20-10-25 to 30-10-25 the number of M. F. varied from 83 to 93.

Case No. II. Elephantiasis (early) of Scrotum and Penis.

Number of M. F. before treatment = 47.

After 13 injections of 28½ grains of Stibosan from 11-10-25 to 27-10-25 the number of M F. varied from 18 to 22 from 28-10-25. to 1-11-25.

Case No. III. Elephantiasis of the right leg.

M. F. in blood = Nil.

After 10 injections of 34½ grains of Stibosan from 24-10-25 to 5-11-25., the maximum diminution in the girth of the Elephantoid limb occurred at level of the malleole and was 1″.

It would appear to us that the effect of an Antimony preparation in Filariasis depends upon the percentage of Antimony in it. 471 not so satisfactory as Sodium Antimony Tartarate.

V. *Treatment of Filariasis at Puri Filariasis Hospital in 1925 by 2% solution of sodium Antimony Tartarate.*

Lymphangitis of Leg, Arm, Scrotum	82.
Filarial Fever.	17.
Elephantiasis of Leg, Arm, Scrotum	37.
Filarial Orchitis	4.
Filarial Synovitis	1.
Filarial abscess	1.
Chyluria	1.

7. Cocoanut oil, a note on its analysis and suggestions for chemical standards of purity.—*By* A. D. Stewart *and* A C. Das Gupta.

8. Chana, a Bengal food stuff, a note on its preparation and analysis, with a suggestion for standards of purity.—*By* A. D. Stewart *and* A. C. Das Gupta.

9. Bacillary Dysentery in the Poona District.—*By* J. A. Manifold.

10. Influence of hardness in water on cooking of Dal (Indian lentils).—*By* A. D. Stewart *and* N. K. Chatterjee.

11. Observations on the Chlorination of water supplies.—*By* F. Barretto.

Deals with the sterilisation of Karachi water supply and dose of bleaching powder necessary to ensure the absence of lactose fermenters in 100 c.c. of the water.

12. Hypochlorite of Soda for water disinfection.—*By* N. N. Inugunti *and* Habib Hasan.

Of various disinfectants, Hypochlorite of Soda was found to be the cheapest and most effective. 1 in 5,000 was found to kill *B. Typhosus* in five minutes, one in 100,000 in one hour, and 1 in 2,000,000 in two hours. Similar results were obtained with Coli and Cholera. Hypochlorite liquor contained 0·25% available chlorine.

13. A note on certain points arising out of variations in technique in the testing of disinfectants.—*By* H. Hawley, T. N. S. Raghavachari *and* P. V. Sitarama Iyer.

14. Cotton Wool Plug test for the detection of Hydrogen Sulphide and its utility in practical Bacteriology.—*By* S. N. Goré.

Hydrogen sulphide like indole is a volatile product of the decomposition of protein by certain bacteria; it can therefore be detected like indole by means of the cotton wool plug technique using lead acetate solution as the reagent. Further, since hydrogen sulphide results from the breaking down of a group of molecules different to that involved in indole production, the presence of hydrogen sulphide and indole can be demonstrated in the same peptone culture by means of the following procedure.

Detection of hydrogen sulphide. The undersurface of the cotton wool plug of the inoculated peptone water tube is moistened with a drop or two of a five per cent. lead acetate solution and the tube incubated at 37°C. for 24 hours. The presence of hydrogen sulphide is indicated by the browning or blackening of the treated plug.

Detection of indole. The upper surface of the plug is now moistened with a drop or two of each of the potassium persulphate and paradimethylamidobenzaldehyde solutions and inserted in an inverted position in to the culture tube. On heating the tube in the water bath for about half an hour or incubating it for a further period of 24 hours, the presence of indole is detected by the pink colouration on the newly treated surface of the plug.

Since the character of generating hydrogen sulphide is possessed by several pathogenic and putrefactive bacteria advantage is taken of this new application of the Cotton Wool Plug technique in the further differentiation of the aerobic intestinal bacilli and in the bacteriological examination of water.

15. Koser's citrate utilisation test as applied to water supplies in the Madras Presidency.—T. N. S. Raghavachari.

16. Development and duration of protection after prophylactic inoculation of Vaccines sterilized by different Methods.—*By* K. R. K. Iyengar.

The organism used was that of fowl cholera (*B. avisepticus*). The vaccine made from this organism was sterilized (1) by heat at various temperatures—and the subsequent addition of 0·5 per cent carbolic acid (2) by the addition of 0·5 per cent carbolic acid only. Two prophylactic doses of .04 mgm and ·08 mgm were given intravenously to pigeons at weekly intervals. The testing doses of living virulent *B. avisepticus* were administered intravenously 7 days after the first dose and at varying intervals after the second dose till the degree of immunity fell to zero or nearly zero. The agglutination response was also investigated with a view to determine whether that development was an index of protection.

Conclusions.

(1) As regards development and duration of immunity, the vaccines sterilized by heating at 40°C. and 60°C. for half an hour with subsequent addition of 0·5 per cent carbolic acid were as efficient as the vaccine sterilized by carbolic acid only.

(2) The vaccine heated to 80°C. had lost considerably in antigenic potency.

(3) Agglutination response does not correspond to protection.

17. Chemo-Therapy of Plague.—*By* P. T. Patel.

The paper embodies the results obtained by the treatment of plague with iodine and its preparations, carbolic acid, izal, mercurial preparations, mercurochrome, neo-salvarsan, protein shock by means of milk, and adrenaline chloride. None of these have yielded results that can be claimed beneficial.

18. Chemo-Therapy of Plague.—*By* B. P. B. Naidu.

Mercurochrome in the treatment of experimental plague in rats and in rabbits.

19. Sensitised Plague Vaccine in the treatment of experimental plague in rats.—*By* B. P. B. NAIDU.

20. Notes on the potency of Haffkine's plague prophylactic. —*By* B. P. B. NAIDU, C. R. AVARI, *and* R. H. MALONE.

Experiments undertaken to test the potency of the prophylactic and of its constituents, and the factors which are considered to have an influence on the potency of the vaccine, show that (1) the prophylactic in a dose of 0·5. c.c. produces an average mortality of 23·3% from toxaemia and confers a percentage immunity of 33·9. (2) among the protected rats, deaths from plague are spread over a longer period; (3) the supernatant fluid is slightly less toxic than the whole prophylactic and confers about the same degree of protection, while the sediment is the least toxic and confers only a slight degree of immunity; (4) different brews of the prophylactic maintain a fairly uniform standard of protective value; but occasionally, for reasons not yet understood, a brew may fall considerably below the standard. In view of this, it is advisable to test the potency of the brew before it is used, (5) neutralisation of the prophylactic does not improve its potency, nor reduce its toxicity, (6) the potency of the prophylactic increases with the period of incubation reaching its maximum at the end of five weeks and remains constant up to sixteen weeks; after which both its potency and toxicity gradually diminish, (7) storage of the prophylactic for six months has no deleterious effect on its potency; a slight diminution in the potency takes place when stored for a further period of twelve months. The mortality from toxemia following on the inoculation of the prophylactic is high when used within a month of storage, but becomes less if stored for a longer period, and (8) the potency of the prophylactic depends on the virulence of *B. pestis* employed in its manufacture. Virulence of plague bacilli is raised by repeated passages through rats.

21. Notes on the culture medium used for the growth of *B. pestis*.—*By* B. P. B. NAIDU, C. R. AVARI, *and* R. H. MALONE.

(1) The hydrogen-ion concentration of the medium used for the preparation of the plague prophylactic is at its optimum.

(2) The nutrient broth employed in the manufacture of the prophylactic is neither toxic nor has it any immunising power for rats.

(3) The growth of *B. pestis* is attended with proteolytic changes which ultimately lead to the formation of ammonia.

(4) The alkalinity of the medium increases steadily during the first five to seven weeks and then passes through a series of rises and falls.

22. Work on helminthic infections at the Puri Filariasis Laboratory.—*By* P. N. DAS, *and* S. C. BASU.

I. Incidence of Ankylostoma Necator and S. S. Infections.

Identification of Ankylostoma and Necator by examination of the faeces for adult parasites after administration of Carbon Tetrachloride. Question of the percentage of infections.

Predominance of Necator infection.

194 samples of faeces examined for Ova and Larvae (S. S. infection) with the following results:—

Ankylostoma or Necator Infection=64%.
Strongyloides Stercoralis Infection=23%.
Negative=13%.

In 22 samples of faeces, the adult parasites were examined after treatment by Carbon Tetrachloride with the following results:—

Pure Necator = 19.
Ankylostoma = 2.
Mixed Necator and Ankylostoma = 1.
Percentage of Necator infection — 86·30%.

II. Helminth Ova in faeces.

Morphology of Ova.

Technique of counting Ova per gram of faeces and etc.

In 39 cases, the Ova were counted, the number varied from 100 to 800 per gram of faeces.

III. Culture of Larvae in Faeces.

Morphology and identification of Larvae. Ankylostoma and Necator confirmed by examination of the adult parasites after treatment.

S. S. Larvae.

IV. Pathogensis of Helminthic infections.

V. Treatment of Helminthic Infections by Carbon Tetrachloride.

97 cases treated in 1925 up to 30-7-25. Ova of Ankylostoma or Necator disappeared from the faeces after 1st. treatment of Carbon Tetrachloride in 70% of cases.

Carbon Tetrachloride was administered in 17 cases of S. S. infection.

After 1st treatment Larvae were not found in 6 cases which were cases of mild infection.

Second treatment could be given in two cases.

Larvae disappeared only in one case.

23. Medical inspection of school children at Simla.—*By* J. R. Webb.

The paper deals with the medical inspection of school boys and gives the statistics obtained in such inspections from the commencement of the scheme in September, 1923. Certain diseases, such as enlarged tonsils, adenoids, eye diseases, caries of the teeth, diseases of the ear, state of vaccination, are compared with conditions in England and Wales. The statistics of enlarged spleen and infectious diseases are given.

24. The method of Periodogram analysis and its application in the study of the epidemiology of cholera in India.—*By* A. J. H. RUSSELL, *and* R. SUNDARARAJAN.

(1) Analysis by the Periodogram method and its application by Brownlee to the statistics of measles in London and other English towns.

(2) Periodograms obtained by analysis of cholera statistics in different provinces of India over the last thirty years.

(3) Possible inferences and practical applications to be derived from those periodograms.

25. A summary of the clinical work of the sprue investigation carried out by officers of the Haffkine institute. —*By* G. D. CHITRE.

26. Gastric, intestinal and urine analysis in cases of sprue. —*By* M. A. MALANDKAR.

A condition of hypoacidity is frequent in sprue. Achlorhydria is met with in acute cases. The hypoacidity is not due to lack of secretion of HCl, but to neutralisation by regurgitation of the alkaline contents of the duodenum. Fat content of the faeces in sprue is high. It may be due to excretion of fat by the intestines rather than to a defect in pancreatic function or lack of bile secretion. Urine did not show a material departure from the normal.

27. A simple method for the estimation of fat in faeces.—*By* S. N. GORÉ, *and* K. H. BHARUCHA.

Since different specimens of faeces vary so much in consistency, it is essential that the percentage results should be expressed in terms of the dry weight of faeces. To effect this it is not necessary to dry the faeces en masse to constant weight as has been recommended by Cammidge and others.

It has been determined that 10 c.c. quantities of a fairly thick uniform suspension of faeces when dried to constant weight in platinum basins do not show a variation of more than ± 1 per cent in their residues. A twenty per cent suspension of a formed stool made in distilled water (w. v.) gives a consistency such that 10 c.c. contain about 0·5 grammes of the dry weight of faeces. If the faeces are liquid they are used as such; if watery they are evaporated to about the right consistency on the water bath.

For the purpose of extracting fat, 10 c.c. of the suspension are poured on and distributed over a strip of absorbent fat-free paper as used by Adam in estimating fat in milk. The strip is dried in the sun or in a steam oven. It is then loosely rolled up and the fat extracted either (*a*) in a Soxhlet apparatus or (*b*) in a 50 c.c. glass stoppered cylinder. For the determination of total fats 10 c.c. of the suspension are first heated with 3 c.c. of strong hydrochloric acid and then treated as above.

Thus by means of this procedure the time required for drying faeces is greatly shortened and if the cylinder method of extraction is used several samples may be dealt with simultaneously.

28. Blood analysis in sprue.—*By* S. K. GOKHALE.

Van den Bergh's reaction for the presence of bile pigment shows that bile pigment is absent from serum in sprue. This differentiates sprue from pernicious anæmia. There is a definite decrease in the ionic calcium in sprue and a slight increase in the non-protein nitrogen and the chlorides Sugar, cholesterol, fatty acids, fibrin, albumin and globulin were present in quantities within normal limits.

29. The nature of blood creatinine.—*By* CLIVE NEWCOMB.

30. Bombay Anæmia.—*By* P. N. BASU.

31. The Piroplamoses of Cattle in India.—*By* HUGH COOPER.

The term "piroplasm" is a convenient comprehensive name covering a number of different species of intra-corpuscular protozoan blood parasites, all of which are transmitted naturally by the agency of ticks. Of some seven species described in cattle in different parts of the world two (or three, if one includes the one other probably unimportant species so far recorded from buffaloes only) have been detected in cattle in India. Both parasites have a very wide distribution. Usually they occur as latent or "carrier" infections and cause no recognisable harm to the host. Under certain circumstances, however, each has been shown to be responsible for serious and sometimes fatal disease.

Babesia bigeminum (Smith and Kilborne, 1893) is responsibl for by far the greater amount of damage to cattle. As very young calves possess a high degree of natural resistance, the disease in its serious form occurs in adult animals only. Cattle that are imported into India are especially liable to suffer. In addition to infection of "clean" adult animals, resuscitation of "carrier" infection may also give rise to serious complications. A number of conditions resulting in depression of the vitality of the animal are probably responsible for such resuscitation, but special importance must be attached to the relationship that exists between this infection and rinderpest. Resuscitation of coccidiosis is known to be a possibly serious complicating factor in rinderpest, and also the introduction of infection into "clean" animals may occur in the "serum simultaneous" method of immunisation, where blood is used. Fortunately this form of piroplasmosis is readily amenable to treatment with a drug, namely, trypanblue.

Theileria mutans (Theiler, 1906). Until recently this small parasite was believed to be non-pathogenic. As it occurs in the circulating blood, however, it is indistinguishable from the very highly pathogenic parasite *T. parva*, the cause of East Coast fever of Africa. The main distinguishing feature has been held to be the presence of developmental forms, known as "blue bodies," found in the lymphatic tissues in *T. parva* infection, and the absence of these bodies in *T. mutans* infection. In a few cases, however, "blue bodies", indistinguishable from those of *T. parva*, have been detected in the tissues of cattle at Muktesar which have died of acute theileriasis (*T. mutans* infection). Experimental evidence has also been brought forward recently by Brumpt (1923), working in France, and by Doyle (1924), working in Egypt, in support of the view that *T. parva* is probably only a particularly virulent strain or variant of *T. mutans*.

32. The Coccidia of Cattle in India.—*By* HUGH COOPER.

Recent studies at Muktesar have shown that *Eimeria zurni* (Rivolta, 1878), which has been recorded from cattle in many parts of the world, is of almost constant occurrence in the intestinal tract of cattle, although the infection has apparently hitherto escaped detection in India.

The ripe oocysts passed out with the faeces show extreme variation in size and shape, and the variations appear to be closely connected with the rate of multiplication. In the "normal" carrier infection all oocysts are well formed with a strong and thick capsule, and with a relatively large amount of dense and granular protoplasm. Both very large and extremely small forms are then encountered, and they display a considerable range of variation in shape. In certain circumstances the restraint upon multiplication ordinarily exercised by the intestinal mucous membrane becomes relaxed, and in direct relationship with the rate of multiplication which then occurs, uniformity in size results. At the height of multiplication oocysts are small and their measurements fall within a limited range, and all of them then show also an almost uniformly ovoid to a nearly round shape, with distinctly thinner capsules. This form may be referred to as the "type," for it is probably the one seen by Zurn originally; it is the one most easily detected on account of its appearance always in very large numbers, and it is the form which has been described by most workers in other countries.

When clinical disease, characterised as a true dysentery, occurs as a result of almost unrestrained multiplication, following upon the stage of maximum production of the "type" oocysts, a further change in form is observed. A uniform, and still smaller, oocyst appears, usually in small numbers only, having an extremely thin capsule and a much reduced amount of protoplasm, which is almost transparent. This form is referred to as the "delicate" form. In a sample of faeces, therefore, it is often possible to distinguish between "infection," "affection" and "clinical coccidiosis" by the form and number of oocysts detected.

Unlike the coccidia of most other animals, full sporogonous development of bovine *Eimeria* does not easily take place *in vitro*. For such development peculiarly exacting and as yet ill understood moisture conditions would appear to be necessary.

Isospora sp. has recently been detected in a small number of cattle in Assam, but detailed study of these parasites has not yet been possible.

33. Three new species of yeasts obtained from the waters of the mineral springs.—*By* MADAME EMANUELOV.

34. Human cases of *B. suipestifer* infection in Bombay.—*By* P. N. BASU.

In four cases of pyrexia, one of which was fatal, the *B. suipestifer* was isolated.

In two cases this organism was obtained by blood culture during life, in a third case it was found in the stools and in the fourth case, and in first who died, it was found in the gall bladder.

Where this bacillus was isolated from the blood the autosera gave agglutination in dilutions up to 1 in 25.

The organism ferments glucose, mannite, galactose, laevulose, xylose, and arabinose, and does not ferment lactose, saccharose, inulin, and raffinose. Citrated milk becomes first acid and then alkaline after 72 hours. Indol and V. and P. reactions were negative. Two out of the four strains gave acid and gas in dulcite.

Agglutination with high titre sera gave

Para A—negative.
Para B—negative.
Para C—incomplete agglutination up to 1–640.
B. suipestifer—incomplete from 1–40 to 1–220.

35. The pathogenicity of Bovine Coccidia.—*By* HUGH COOPER.

Coccidiosis has been described as a specific disease of cattle in several countries, under the name of "red dysentery." Hitherto the occurrence of coccidia in cattle has apparently entirely escaped detection in India. Recent studies at Muktesar, however, have shown that a latent or "carrier" type of infection is of almost universal occurrence in cattle in India, and that, although usually innocuous, the parasites are capable, under certain conditions, of overcoming the animal's natural defences and set up a clinical disease identical with what is described in other countries as "red dysentery."

During recent years at Muktesar investigations have been directed with the object of ascertaining the precise conditions under which this ordinarily harmless parasite is enabled to set up the specific disease condition. It has been observed that a condition of clinical coccidiosis frequently occurs as a sequel to severe but not very rapidly fatal rinderpest, while even a mild attack of the disease may result in an appreciable resuscitation of coccidia. A marked symptom of severe rinderpest is diarrhoea, and for the reason that "red dysentery," due to coccidiosis, so frequently occurs as a complication, it is probable that confusion of the symptoms of the two affections has hitherto existed in India, and coccidiosis has not received recognition as a separate disease entity.

The immediate predisposing cause of the disease would appear to be the specific tissue depression of the intestinal mucosa inducing a resuscitation of the lurking organisms, for in a number of other diseases in which marked general depression undoubtedly occurs, no such resuscitation has been detected.

A series of experiments was therefore conducted with a view to ascertaining to what extent the resuscitation of the parasites could be artificially induced by the application of massive doses of certain purgative drugs, the drugs being chosen with reference to the manner in which they were known to act in the animal system, and it was found that the only drugs which answered this purpose were those which exerted a direct irritant effect upon the intestinal epithelium, notably croton oil and aloes. With croton oil typical "red dysentery" of cattle was set up.

36. Malarial infection of mosquitoes in Bombay during epidemic of 1925.—*By* T. G. AKULA.

37. Anti-Malarial operations in connection with the Back Bay Reclamation Scheme of Bombay.—*By* B. S. CHALAM.

The Back Bay scheme consists of the construction of a sea-wall about four miles long. The area thus enclosed, 1,145 acres, is being filled with material obtained by dredging in the harbour and in the Back Bay itself. The dredged material is pumped through pipes to the area to be reclaimed. The material for filling is soft clay which readily fissures and forms depressions while it settles. Collections of water are readily formed and make breeding places. Anopheline larvae have been found in brackish and soft water, and once anopheles were hatched from larvae in water three times more concentrated than sea-water. The following species have been found in the reclamation zone:—*A. subpictus, A. stephensi, A. culicifacies,* and *A. vagus.* Labourers are encamped on the site of the works and some of these labourers are imported from highly malarious districts.

Anti-malarial measures in conjunction with those taken in the adjoining military area by the military authorities had resulted in great reduction of the mosquitoes. In 1921 and 1922 malarial admissions to the British Station Hospital, Colaba, per thousand of strength, were 972 and 387 respectively. After anti-malarial work, the malarial admissions in Colaba in 1923 and 1924 dropped to 152 and 238 respectively. These years were said to be bad years as regards malarial incidence in the rest of the city of Bombay.

38. Artificial pneumothorax treatment in advanced Pulmonary Tuberculosis.—*By* M. KESAVA PAI *and* A. R. PARASURAM.

The investigation forming the subject of the paper is based on the experience of the first 100 cases of pulmonary tuberculosis treated at the Government Tuberculosis Hospital of Madras during the years 1924 and 1925. Of these 100 cases 87 were in the III stage, 12 in the II stage and one in the I stage. In 26 of the cases a good pneumothorax could be induced in spite of slight adhesions in some of them; 63 allowed only partial pneumothorax and in 11 induction of pneumothorax was quite impossible on account of complete adhesions.

66% of the good pneumothorax cases are either cured or on the way towards arrest and the rest are improved to a greater or less extent. About 10% of the partial pneumothorax cases are progressing towards arrest, but none of the failures with complete adhesions.

Though the benefit in good and complete pneumothorax is rapid and remarkable, the effect of the partial pneumothorax if carried on with perseverance over long periods of time is often very beneficial.

The idea that the contralateral lung should be either free from disease or slightly diseased, for the treatment to be considered suitable, requires considerable modification in view of the results obtained. Not only does the diseased lung steadily improve by the collapse, but the opposite lung undergoes repair as a result of the lessening of the toxaemia.

Artificial pneumothorax is the method of treatment 'par excellence' for advanced pulmonary tuberculosis, and should be given a trial even though there is considerable involvement of the opposite lung. The best results are obtained by a combination of pneumothorax and Sanatorium treatment.

The advantages of the treatment over the older methods are the rapidity with which recovery takes place and the quickness with which bacilli disappear from the sputum, both factors being of considerable value from the epidemiological standpoint and in the prevention of infection in the home.

Artificial pneumothorax treatment has the decided advantage over Sanatorium treatment that it can be conduced in crowded cities and in the home of the patient.

The accidents met with in the earlier days of artificial pneumothorax treatment have now been eliminated by the manometer and other improvements in the apparatus and in the technique, and the contra indications for the treatment are fewer than they were supposed to be at one time.

It is justifiable to attempt the treatment in the very advanced and apparently hopeless cases. Here the results may not be brilliant but the patient is relieved and his life is prolonged and made less miserable.

The apparatus required is simple and with moderate care and skill and X-ray facilities, any qualified medical man ought to be able to apply the treatment in his practice.

Artificial pneumothorax treatment considered from many points of view is the best one that has yet been devised for advanced pulmonary tuberculosis, and succeeds when the other methods are inapplicable or are likely to fail.

39. Complement fixation and lipase in blood sera in Tuberculosis and leprosy.—*By* P. V. Gharpure, *and* G. V. GOLLERKERI.

(*a*) Complement fixation—the method employed consists in using fresh human blood serum from which the complement is not destroyed. The antigen is prepared from Dr. Row's autolysed tubercle vaccine by the opacity method. Haemolytic system is made up by only adding rabbit's washed corpuscles using the human specific ambôceptor. The test is carried out by the drop method. From a purely immunological point of view the power of the antigen to fix the complement is weak but as a ready method as an aid to diagnosis it is both simple and accurate. Except for solitary exceptions the results obtained are consistent—qualitatively and quantitatively.

(*b*) Lipase Estimation.

Method :—2 c.c. serum + 6 c.c. normal saline + 0·6 c.c. Ethyl Butyrate + preservative—24 hours at room temperature

titrated with N/10 NAOH, and control.

The observations go to show that the readings in sera in Tuberculosis are higher than in normal sera and those obtained in Leprosy are higher still.

40. Complement fixation test in the diagnosis and treatment of tuberculosis.—*By* M. KESAVA PAI *and* K. VENKATA RAU.

The test was carried out by the writers in narrow glass tubules of about 3 millimeter calibre by the method adopted by the Medical Research Council, so that a series of parallel tests (1) with Besredka antigen (2) with tubercle bacillary emulsion (3) with a control Wassermann series was carried out with each sample of serum obtained from 5 c.c. of blood drawn by venous puncture. Small quantities of the other reagents being found to be sufficient.

The reaction is not quite specific as a large percentage of syphilitic sera give complement fixation for tubercle antigen. This is due to the presence of lipoids in the latter, to the degree of heating of the serum and to other unknown factors.

As has been noticed by other observers, a fairly large percentage of non-tuberculous sera give a positive tubercle complement fixation reaction including sera from leprosy, malaria etc.

In its specificity the test is of definitely less value than the Wassermann test in syphilis. Whilst certain workers have found it reliable to the extent of 95% and more, others have not been able to elicit more than 56% positive results in the clinically tuberculous. The writers obtained 84·5% positive reactions in tuberculous persons by the combined use of Besredka antigen and bacillary emulsion, but 77% and 76% respectively by the use of these antigens individually in a duplicate series.

About 32% to 40% of clinically non-tuberculous cases give a positive complement fixation reaction with tubercle antigen, but a large number of these are Wassermann positive sera. The percentage of positive reactions in the non-tuberculous, Wassermann negative cases is only 19·6. This latter figure may possibly be partly explained by the fact that the incidence of tubercle infection in the population—amongst whom the work was done was very high as shown by one of us in a separate paper.

23·5% of the cases tested for the tubercle complement fixation reaction were found to give a definite Wassermann reaction. This points to a comparatively large syphilis incidence amongst the tuberculous in the city of Madras.

The writers have not been able to correlate the strength of the reaction with the stage or activity of the disease. A large number of negative reactions have been obtained in very advanced and moribund cases and this is in line with the negative tuberculin reactions obtained in such cases, indicating a deficiency of immune bodies in very advanced tuberculous conditions. The test has not been found to be of any value in prognosis as the strength of the reaction has varied irrespective of the progress of the cases either for the better or otherwise.

41. The relative susceptibility of Indian milch cattle of various breeds to tuberculosis.—*By* M. B. SOPARKAR.

The paper embodies the results of investigation carried out with a view to determining if Indian cattle possessed any greater natural resistance towards tuberculosis than European cattle, to which factor the comparative infrequency of the disease among bovines in this country might be attributed.

Most of the important breeds of cattle in India—bulls as well as buffaloes—were included in the tests.

The results of the experiments appeared to indicate that a certain proportion of Indian calves were possessed of very high powers of resistance towards the infection as compared to English cattle. At the same time there appeared to be a much wider range of individual variation in susceptibility towards tuberculous infection as judged by the varying results of infection obtained, than is noted in English cattle.

This variation appeared, within certain limits, to be independent of the size of the animal.

The resistant animals met with during these experiments were not restricted to any particular breed or breeds employed, but were distributed though not in equal proportions, among most of the breeds tested.

The buffaloes did not appear to be any more resistant than cow calves.

A certain proportion of European cross bred calves also showed a high resistance.

42. Arneth's blood formula and differential leucocyte count in tuberculous conditions.—*By* M. KESAVA PAI *and* K. VENKATA RAU.

The haemoglobin value of the blood does not seem to vary in any characteristic manner in tuberculosis, being about 75% on an average in most cases and in different stages of the disease.

The work of various observers seems to indicate that in early tuberculosis and in arrested cases there is an increase of lymphocytes and of eosinophiles whilst in advanced and cavity cases there is marked polymorphonuclear leucocytosis with decrease of lymphocytes and eosinophiles. Arneth showed in 1904 that his index moved to the left in tuberculosis, the deviation increasing with the stage of the disease. His observations have been generally confirmed by others though the figures given by different workers have varied considerably.

The extreme laevo-deviation described by Arneth and some others has not been noticed by the writers, though definite deviation to the left is no doubt present and varies in intensity with the stage of the disease. The index was found to be 47 in normal individuals, 50·5 in early cases of tuberculosis, 51 in advanced cases, coming down to 44·5 in the fibrosing and recovering cases. The figure for 'normal' individuals being higher than for fibrosing cases is probably due to the fact that our 'normals' were patients who resorted to the Tuberculosis Institute for respiratory affections which were diagnosed as non-tuberculous. There is a paucity of class IV leucocytes in advanced tuberculous conditions, our figure being 13% in such cases as compared with 18% in normal individuals and 21% in fibrosing cases.

The differential leucocyte count gives very consistent results in tuberculous conditions. An increase of polymorphonuclears indicates advanced disease, co-existing with a diminution of lymphocytes and of eosinophiles. There is a lymphocytosis in the early stages of tuberculosis (21·5%) and in the fibrotic stage (22%). The lymphocytes are considerably decreased in the advanced and toxaemic conditions (17% and 15%). Eosinophiles which form 2% of the total leucocytes in health rise to 3·5% in early tuberculosis and fall to 2·5% in the later stages and to 2% and lower in the sinking cases.

43. Cutaneous tuberculin test in tuberculous infection.—*By* M. KESAVA PAI, *and* C. A. VENUGOPAUL.

Since the introduction of the cutaneous tuberculin test by Von Pirquet and Naegeli in 1907, a good deal of work has been done on the value of the test in the diagnosis of tuberculosis both of the latent and of the active type.

The test signifies infection with the tubercle bacillus at some period of life. The new born infant does not react to tuberculin and positive reactions increase with age. Some observers have doubted the specificity of the reaction and it has been asserted that other organic extractives give skin reactions in the tuberculous.

The reaction is totally absent in a number of advanced cases of tuberculosis and in some cases of ordinary tuberculosis with superinfections like measles, influenza, and pneumonia.

The epidemiological and clinical value of the test has been studied by the writers by an analysis of over 4,000 cases that attended the King Edward VII Tuberculosis Institute of Madras during the year ending September, 1925, either for tuberculosis or suspected tuberculosis, most of the patients suffering from respiratory affections.

The test was carried out with 100% and 50% old tuberculin with a saline and glycerine control and the results recorded at the end of 24 hours or longer.

Taking the positive reactions as the 'infection rate' it was found that by the end of the first year of life about 40% of the children get infected, by the end of the second year 65·7%, and by the fifth year 80·9%. No marked difference can be noticed in this incidence between males and females, though in the age period of 0-5 years the infection rate amongst female children seems to be higher than amongst male children.

Figures for incidence of infection have varied in the hands of different observers and in different parts of the world, and it has been found that the infection rate is low in countries where incidence and mortality from active tuberculosis is also low.

Variations have also been observed as being due to social and economic factors, overcrowding, city or country life, selection of the material, and the method of recording the results.

The clinical value of the test is not decisive. The percentage of positive reactions are higher in the tuberculous than in the non-tuberculous. Even a strongly positive Von Pirquet reaction may be elicited in a clinically non-tuberculous individual. The value of the test is of a confirmatory nature only, when combined with signs and symptoms. An absence of the reaction is strongly suggestive of the condition being non-tuberculous even when signs and suspicious symptoms are present; but there are exceptions to this rule. 96·7% positive reactions of various degrees and 49·8% strong reactions have been obtained in clinically tuberculous individuals, the figures for these amongst the clinically non-tuberculous being 91·4% and 31·2% respectively.

Hypersensitiveness to tuberculin as indicated by violent cutaneous reactions are considered to be contra-indications to tuberculin treatment, whilst cases giving ordinary sensitivity are suitable for the treatment, other conditions being favourable. Cases where the control also gives a strong reaction have a bad prognosis.

Individuals clinically non-tuberculous but yet hypersensitive to tuberculin, should be closely watched, as they not infrequently develop tuberculosis of an active type within a fairly short time after noting the results.

44. Curative value of an autolysed tubercle baciliary culture-vaccine in leprosy.—*By* R. Row.

In previous communications the author has described the technique[1] of the preparation of the autolysed and defatted vaccine, and also its chemical, biochemical, microscopic, physiological and therapeutic properties. While applying the vaccine in tuberculous infections it was noted that with a weekly dose of 0.025mg. subcutaneously of this vaccine which was borne well without any general or focal reaction, or local inconvenience (if at all, very slight), the effect in man was on the whole a distinct benefit when persevered with for some time. On the strength of these findings, and in the light of the facts gathered in the course of another investigation on the comparative antigenic value of the autolysed vaccine in tuberculous and leprous sera—as seen from the complement fixation test, where it was found that the antibody content in the latter was 3 to 4 times that in the former,—an attempt was made to extend the application of this vaccine to nerve and nodular Leprosy, and the following results have been recorded after a course of treatment lasting 5 months or more. Here are a few cases :—

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[1] Technique of preparing the vaccine :—

T.B. grown on sold media for over four weeks, (I have used 3 per cent. Glycerinated Brain Agar) is scraped off and made into an emulsion in sterile normal saline and after treating the same to toluene so as to kill the bacilli but not the ferments, it is allowed to autolyse at 37°C for several weeks until the autolysis has completed the disappearance of the acid fast material of the T.B., as seen by microscopic examination from time to time. Then the whole mass of the bacilli is treated to an excess of some fat solvent, like Petroleum-ether or Xylol, for some weeks with repeated shakings until the fatty acids are all removed. It is then collected, dried, weighed and made into vaccine of definite strength in normal saline.

The first patient, Fernandes, 35, a fitter, gave a history of anæsthesia of some part of his legs and feet, of 12 months' duration, and when first seen, in June 1924, he had the following lesions : Trophic ulcerative patches in the lower third of the left leg, which was completely anæsthetic, the anæsthesia being well defined by a glossy condition of the area and loss of hair and discoloration. The other anæsthetic areas were in both the feet with loss of power in moving the last two toes. The soles of the feet were partially numb. The hands were also glossy and anæsthetic up to the lower third of the forearms, more pronounced in the left than on the right side, with a slight though undoubted atrophy of the interossei muscles. The Ulnar nerves on both sides were very thick and felt at the elbows as hard cords. The "Auricularis magnus" nerves appeared sticking out like lead pencils under the skin. The face appeared glossy but there was no alteration of the features or thickening of the ears nor any nodules. B.L. were found in the nasal secretion.

The condition in December 1924 after a course of 35 injections.

The general appearance is merry and bright. The glossy condition of the face not marked. The hard Auriculares magni nerves can neither be seen nor felt. The ulnars are still large but greatly reduced in size. The trophic ulcers are completely healed up leaving a shiny skin with sprouting hair in the situations. The cutaneous anæsthesia has almost completely disappeared in these parts as well as in the hands. The only parts which are obstinate are the two outer toes of the right foot, which are partially shrunk ; the more so, the fourth toe, which has not recovered the power of movement. All anæsthetic areas which have recovered are slightly glossy.

November, 1925.

The treatment was continued fortnightly instead of weekly for the last six months. The patient is practically recovered, but the fourth right toe is still anæsthetic and atrophied.

Two similar cases of nerve leprosy with perforating ulcers of the foot have come under the vaccine treatment since May last, and have also improved in every way with regard to general appearance, anæsthesia and trophic lesions, but are not yet quite free from the vulnerability (of the healed parts) on the slightest provocation. The improvement observed in these two, though not so complete, is enough to confirm the curative value of the vaccine as shown by the first patient.

The results obtained in nodular leprosy are more striking than in nerve leprosy, as the appearance of the patient gives a clear index as to the progress and is demonstrable in photographs.

Here is an account of two such cases who have come this year (1925) under the author's Vaccine Treatment and observation :—

25-7-1925.

Patient (1).—Bankat Singh, 56, landlord, Berars ; history of 1 year Leonine features with thickened and anæsthetic areas about the cheeks, eyebrows and forehead, with partial loss of hair from the eyebrows. Ears slightly thickened and anæsthetic but no localised nodules ; large patches of anæsthesia with well marked margin, which is raised, in the right and left fore arms, and in the left arm about the elbow with atrophy of the thenar and hypothenar eminences ; thickened ulnar nerves ; similar patches of anæsthesia about the right knee.

24-11-25.

After 25 injections of the vaccine (0·025mg.) the thickening about the eye brows and cheeks is greatly reduced. The features-show more normal contours. Anæsthesia has disappeared in the parts affected both in the face, hands and elbows. The thickened margins of anæsthetic patches are now flush with the skin.

There is a return of growth of hair in the parts which were anæsthetic, e.g. in the eyebrows and the left arm. The only evidence of there having been anæsthesia is a deeper pigmentation of the skin. The atrophied thenar and hypothenar eminences and wasted interossei of the hands are stationary. The ulnar nerves are reduced markedly. The patient's general condition is good as is his sense of well-being.

Patient (2).—Mahadev, 20, mill-operative, Bombay, duration 8 months (?)

19-7-25. Has an anæsthetic patch on the radial side of the right wrist and the lower third of the forearm. Complete atrophy of the thenar eminence and wasting of the right interossei giving the characteristic appearance of "main-en-griffe." The right ulnar nerve is thickened. The nodules on the face and the right ear well marked and unmistakable, some being as large as large peas. Diagnosis was confirmed bacteriologically.

25-11-25. Has had over 15 injections (0·025mgs,); the treatment was interrupted for six weeks during the Mill strike in September and October, 1925. All the nodules of the face and ear with the exception of two on the left side of the nose have completely disappeared leaving only a slight discoloration; and even these two are very small. The facial features have returned to normal. So also the right thickened ulnar nerve.

From the above the following conclusions can be drawn :—

(1) Thickened nerve trunks become small and assume normal size.

(2) Anæsthetic areas lose the anæsthesia, become glossy at first and resume practically normal conditions with the growth of hair where this is lost.

(3) The margins of these areas become flush with the surrounding skin and beyond a slight discoloration nothing abnormal can be noticed in these areas.

(4) Trophic and perforating ulcers heal up rapidly, but in some cases the vulnerability of the parts remains very marked even after the healing of the ulcers.

(5) Atrophied muscles remain so, and if at all recovering, they are very slow in doing so and probably remain as such if the disease has destroyed the muscular tissue.

(6) In disfigured conditions of the face the vaccine seems to be of benefit in restoring the natural contour of the features, the thickened parts gradually melting away

(7) In defined nodular lesions a prolonged course of the vaccine leads to their complete absorption leading to the normal return of the features.

The first 3 or 4 injections may produce no change in the focal reaction, but may sometimes make them appear a little angry.

45. Recent methods of differentiating lactose fermenting organisms as applied to Indian conditions.—*By* J. CUNNINGHAM *and* T. N. S. RAGHAVACHARI.

Section of Anthropology.

President :—N. SUBRAMHANYA AIYAR, M.A.

Presidential Address.

ANTHROPOLOGY AND ITS PLACE IN THE WORLD'S ECONOMY.

LADIES AND GENTLEMEN,

It was with great diffidence, though with unspeakable gratitude, that I accepted the kind invitation of the Executive Committee of the Indian Science Congress to preside at this section of its great Conference. It came to me through a very unhappy incident. The great septuagenarian naturalist worker, Rai Bahadur, B. A. Gupte, who last held the high office of the Assistant Director of Ethnography, having unfortunately died subsequent to his acceptance of the presidentship, it fell to the forlorn secretaries of the Congress to offer the honour to me, and it fell to my own grasping self to seize it. Although I have done some work in Ethnography and allied fields in Travancore as Census Commissioner, Superintendent of Ethnography and Officer-in-Charge of the Gazetteer, my later-day labours have been chiefly in the Department of General Administration; and my only claim, if claim it may be called, to preside at an Anthropological gathering is that I have always believed in Anthropology as the unerring key to Universal Welfare, than which there can be no higher goal for man. I shall therefore speak to-day, with your leave, not on Anthropology in any of its numerous and most interesting technical aspects, on which, I am sure, the learned papers that are going to be read will throw a flood of original light, but shall confine myself to a few observations on Anthropology with reference to its general place in the economy of the world's life, now and for all time. I shall not attempt to do more, for which I crave your forgiveness and your indulgence.

ANTHROPOLOGY—ITS DEFINITION AND SCOPE.

What is Anthropology? As the term indicates, it is the science of man, of the human species known in biological language as *Homo sapiens*. If that is the definition of Anthropology, I wish to make a preliminary appeal to you to consider whether the function of Anthropology can be anything higher or other than the making and keeping him as *Homo sapiens* or 'wise man'—i.e. not merely by way of contrast to *Homo Neanderthalensis*, but as the reverse of *Homo Stultus* (or the stupid man) or *Homo Stultissimus*, (or man, the superfool), as Professor Richet, the Nobel Prize-man for Physiology, would suggest. Certainly, man *must* deserve to be called *Homo-Sapiens* in every sense of the term; but he *can* be that only in the measure in which he does his function in the world's economy

Now, what is the function of the human species? Everything—by 'thing' being meant a form that can appeal to one or more of the five senses, viz., touch, sight, taste, hearing and smelling, as otherwise there can be no existence—has a function or quality attaching to it. And "Universe" is merely a term to denote the group of *all* things, in earth or heaven or in all the fourteen worlds spoken of in Scriptures, visible or invisible, coarse or tenuous, material or spiritual, animate or inanimate—man being but one of those "things." And just as, in respect of all *other* things in the Universe, having both form (or structure) and function (or quality), there are separate sciences that deal with the form on the one hand and with the function on the other, there must be a similar set of sciences with reference to man. While the sciences relating to form will deal with his origin, his growth, his development, the description of his component parts including minute structure, and also the function of one part to another—in fact, of all that relates to him taken by himself and *without* reference to other things,—the science of function will treat of what that man has to do *with reference* to other things. Let us apply this, first to man as an individual and then to the species. We shall find that in regard to the individual, man, there is the science of "Embryology", or the story of his origin, growth and development in the womb; there is his anatomy (including histology) which is a description of his organs, macroscopic and microscopic. There is also physiology and there is psychology, which deal with the functions of the various parts or organs one to another—physical and mental. Now, taking man as a *species*, we have Anthropogeny with its subsidiary science of Anthropometry, which discusses the question of his origin and explains the processes of that origin and growth, and which will correspond to the embryology of the individual man. There is then the formation and life history of the various races or sub-species of the main species, *Homo*, and the description of their varied customs, manners, habits and beliefs, called Ethnology and Ethnography respectively, or "Anthropography" to use a more inclusive term. This will be the anatomy and histology of the human species. We have also national and international sociology and general ethics, dealing with the relations between the various nations and races of mankind and between parts of the same nation. These will be the physiology and hygiene of the human species. And lastly, we have history and political economy, which may be said to correspond to the clinical records and the emergency prescription-books of the human individual. But all these sciences, Anthropogeny, Anthropometry, Ethnology, Ethnography, Sociology, Ethics, History, etc., relate only to the structure or form of the human species. None of them deal with his function to the rest of the Universe. And it is that primarily which I propose to deal with to-day. If man is *Homo Sapiens*, he is the brain of the cosmic organism and has therefore a function similar to that of the brain in the physical organism: and the real function of Anthropology is, I take it, to deal with that function.

SHOULD THE UNIVERSE OF THINGS LIVE IN A STATE OF MUTUAL FUNCTIONING AT ALL?

It may be asked, why should the Universe of things live in a state of mutual functioning? Why should the human species regard itself as an organ with a function to a vaster organism? Why should it not regard itself as a self-contained, complete whole, and deal with all the other things, according as the needs of its own organism may demand from time to time? The answer is, yes. It may do so, *provided* the thing called the human species *can* live unaffected by the activities of all other species and things. But it *cannot* so live. The Universe is an inter-connected, dynamic whole, with no empty space in or between things and no inanimateness or lifelessness in any thing. That plants have life is the recent demonstration of our illustrious countryman Professor Bose. That all things are divine or that divinity is omnipresent—and to be divine is certainly not to be dead—is the teaching of religion. In such an animate Universe, things *must* affect each other, either well or ill. A state of neutrality cannot be conceived of. If they are helpfully connected, so that one thing serves another either directly or indirectly, *all* things will live unchanged and in eternal bliss. There will be, in other words, absolute, collective or *Universal* salvation. But if the things are *not* so connected, if the activity of each thing tends to harm or destroy every other thing, directly or indirectly, all will have to live subject to perpetual change and consequent misery of some kind or degree, some more than others, some now, others at another time. But there will be a limit in time, degree and extent for the life and happiness of *everything*. No one thing will have absolute happiness, nor can *all* parts be *equally* happy at *any* time. And this is the result of misconnection, or mutually harmful connection. On the other hand, mutually helpful connection means functional connection. Here everything performs a separate function to every other, just as every thing has a different structure from every other. And just as the human species has its own structure, differing from that of all other things, it must have also its own distinctive function. And that function is to create if absent, to safe-guard if present, to repair if in disrepair, and to recreate if wholly destroyed, mutual functioning in the cosmic organism; and in the meanwhile, it must fit its own self, and keep itself fit, to do that function well. This is real Anthropology,—all other sciences usually included under Anthropology being only sciences that relate to the *structure* of the human species and having only a subsidiary value, and that only when rightly used.

THE STATE OF THE HUMAN SPECIES TO-DAY.

Such being the definition and such the scope of the great science of Anthropology, let us see how the human species stands at present. Is it in itself a well-arranged organism? For, unless it is, mutually functioning in all its parts, it cannot serve as an organ to a larger organism. Now, mankind is seen distributed into so many territorial units, called nations, races or peoples; and each of them is divided into so many families, the nature and stability of whose connection one with the other determines the measure of its civilization The more intimate and the more responsible the connection between family and family, and sex and sex, the higher is that people in mankind's scale. The less intimate and the less responsible, the lower will be their place in that scale. Ethnologists have in this light divided mankind into three classes, savage, barbarian and civilized, corresponding, it is said, to the Stone, the Bronze and the Iron ages of man. But, is the state of connection all that can be desired even among these civilized peoples? Even among the members of the same family, we do not see the right connection. It is not one of mutual responsible functioning at all. If I love and cherish my wife, it is only because she *deserves* to be loved, not because I have a *duty* to love and cherish her. In other words, I love her only as much as, and as long as, she deserves to be loved. It is no question of man loving woman, or woman loving man, as a duty or function to the family organism. And unless there is that idea, there cannot be a sense of duty to do that function, a sense of responsibility to keep oneself able to do it and to enable her and him to deserve its being done. With such an imperfect family ideal, the relationship between *groups* of families—industrial, commercial, ruling or religious, call them classes, sects or castes—cannot be better. I love the king, and feel loyal to him, simply because the particular King *deserves* my love and loyalty, and not because he is a functioning organ of my own body-politic. I shall therefore love him and be loyal to him only as much as, and as long as, he deserves my love and loyalty. As soon as his deserving lessens, I throw him clean overboard and either rule myself or get ruled in any way it may please me from time to time. In the same manner, if I buy my country's goods or buy from and sell to my country's tradesmen, if I invest my savings with my country's bankers, or if I accept and pay for the religious ministration of my country's priests, it is only because, and to the extent, and for the period, the producing, distributing or religious organs respectively deserve my patronage. In fact, the idea of unshirkable mutual responsibility is non-existent altogether. Annullable contract determined by individual necessity, and not inalienable status established on considerations of collective welfare, is now the principle of life, whether it be between sexes in a family or between classes in a nation.

And when I have no idea of living a mutually responsible, interdependent life within my home or country, how can responsible relationship be expected between peoples calling themselves different nationalities and occupying separate territorial areas? In other words, how can there be any international unity? How can the sacred questions arise, namely, "Should I not connect myself in responsible helpfulness with my brethren of all the other nations of the world? In the case of people who are not yet fully organised or organised quite to my nation's level, should I not help to organise them and make them organs of the larger organism of humanity? And should I not use every knowledge for that purpose, and none to exploit them, no matter whether I regard them as ascendants of Simean ancestors or as the survivals of an once great people. Should I not in, the former case, enable them to grow to their full proportions without diminution in numbers or individuality, and in the latter, strive to make them great once more, and that with their own distinctive personalities? And should not all ethnological and ethnographical researches be harnessed to that holy purpose?" These are no doubt most saintly questions. But they will never arise as long as there is no idea of organism, or inter-organic function or responsibility, among things in nature. On the other hand, the only questions that can and do arise, are the questions of the savage—viz. "Why *should* I seek any responsible connection with other people in the world, why even with my own fellow territorials, except to the extent that my immediate interests require? Why *should* I help to organise the people who are not organised and enable them to live and grow like myself? Is it not investing in my possible rival for my own destruction? How can the prosperity of other people help, much less be necessary for, my prosperity? And why should I not therefore, as a people, exploit the natural weaknesses or artificial handicaps of other peoples and live and thrive all the better, first subjugating them and eventually absorbing them, just as individual man owns and rears animals and plants, only to eat and thrive on them—a case of subordinating love to hatred, positive to negative qualities?

This is exactly what is being done, and all inventions and discoveries of science, are used for this purpose of mutual exploitation. And it is a common complaint that the greater the advances of science the less the peace and happiness of mankind.

THE RESPONSIBILITY OF SCIENCE DISCUSSED.

But certainly, it is neither a match-box nor its maker that is responsible for the acts of an incendiary. And if science is only that, it will be not more responsible for the bad use that is made of it. It is in this view that Professor Lamb, speaking as the President of the British Association, which to the Empire is what the Indian Science Congress is to us, asked at its last session, "Why should science be held responsible for the failure of hopes which it can never have authorised." "Its province," he said, "is vast, but has its limits. It can have no pretensions to improve human nature; it may alter the environment, multiply the resources, widen the intellectual prospect; but it cannot fairly be asked to bear the responsibility for the use which is made of these gifts. That must be determined by other and higher considerations." Here, I must humbly differ. For, does not science say that conflict is the lever of progress, and that it is through conflict that the Universe has been evolved from primordial matter through the various stages of mineral, plant, animal up to man? Is it not this gospel of science, with its struggle for existence, survival of the fittest and elimination of the less fit, that has afforded the excuse and justification for all the competitive policies of modern life, domestic, national and international? And when human society already stands unorganised, making man no free-willed actor in all the tragedy that he is enacting and suffering, and all to meet the purpose of his immediate existence, is it not a pity that science, which ought to show the way to organisation and harmonious and stable interdependence, should teach the very opposite? Is not science therefore guilty? And Professor Lamb, as the redoubtable exponent of that science, does nothing more than join the rest of the world and hold up his hand of horror. He refers man to seek his refuge in "other and higher considerations." But science has really two different departments of activity. One is to give power, and the other to give the knowledge of *how* to use that power. And as long as science has not taught man any other way of using power than to live at each other's expense, science is both the weapon-maker and the weapon-user, and must stand convicted on both counts. And invoking others to bear the blame, which is what the learned Professor does when he says that "the use that is made of the gift of science must be determined by other and higher considerations," does not, therefore, seem fair.

CONSIDERATIONS OF RELIGION.

But what *are* the "other and higher considerations?" The Professor evidently means religious and moral considerations. But what is the religious consideration in essence? It is the fear of offending God's laws. And what is the conception of God in brief? An all-powerful Person, creating the Universe with man in it, giving him freedom to offend His laws, and punishing him for exercising that freedom? If I am wrong in this presentation, I crave to be corrected. Else, may I proceed to submit that if God did *not* want man to offend His laws, He should have either not given him freedom to offend, or He should have so made him as he *would* not offend even if he *could*? To do neither, and yet to punish him for what is really *His* mistake, is ordinarily ununderstandable.

CONSIDERATIONS OF MORALITY.

And as for moral consideration, what is the sanction behind it when the element of religion has been removed? Why should I be moral? Why should I not kill my brother? Why should I not do anything I like, provided I can keep myself safe? Why should I love or serve any, except when and to the extent I *have* to, in my own immediate interest? If that is all the moral consideration, it exists in the animal quite as well. "Wolves and some other beasts of prey hunt in packs, and aid each other in attacking their victims. Pelicans fish in concert. The Himalayan baboons turn over stones to find insects, etc., and when they come to a large one, as many as can stand round turn it over together and share the booty. Social animals mutually defend each other. The males of some animals come to the front when there is danger, and defend the herd with their horns. Instances may be multiplied. Besides love and sympathy, animals exhibit other qualities which in us would be called moral. Dogs possess something very like a conscience. They certainly possess some power of self-command and this does not appear to be wholly the result of fear." In tact, Darwin, from whom the above quotation is made, winds up his chapter on the moral sense by saying that the social instincts—the prime principle of man's moral constitution—with the aid of active intellectual powers and the effects of habit naturally lead to the golden rule, "As you would that man should do to you, do ye to them likewise," and that this lies at the foundation of morality. But he does not seem to have asked himself how this golden rule is compatible with the gospel of conflict, of progressing with the help of one's natural advantage and of a fellow being's natural weakness or handicap. Darwin of course speaks of the *future* welfare of mankind as the goal of evolution, and as a compensation for all the intermediate pains. Evolution is to be a kind of *yagna* or sacrifice, to which the weak may well surrender itself as a sort of pious offering, and to which the strong may even lead the weak through force or diplomacy, commerce or war. But the would-be-victim may well ask 'what has the future done or is going to do for me that I should sacrifice myself now? Am I going to be born again, either with or without memory of the past, and going to resume the activities left unfinished, so as to ultimately lead the Universe including myself to our intended haven? If not, whoever may be born, are they at least to be my direct descendants? Or, are they to be only the descendants of those who have eaten me now? In any case, why should I sacrifice my *present* self for such a remote or false progress, and that for an abstraction called "humanity?" Unless these questions are answered, no willing or conscious sacrifice can be expected. And it is because the evolution of human morals has followed this wrong, because shortsighted, morality of the animal, that Darwin has had to end with a confession that the golden rule has remained a glorious dead letter in the world's annals. The so-called most civilized nations have been no exception. They have only been faithfully following the code of animal morals, though helplessly it must be said, in all their policies, not only in respect of other nations, but between the various classes of their own nations as well. And in the light of this no doubt unconventional presentment of the actual situation, is it not a mere eye-wash to seriously talk of "other and higher considerations" as a determining factor in the use that man makes of the results of scientific knowledge?

COMPROMISE IN COSMOGENY.

Compromise with truth is wrong in all departments of activity, much more so when momentous questions affecting the whole Universe are concerned. Though there may be many answers to a question, there can be only one correct answer. And with that right answer, there should be no parleying. There is the Universe, which is the collective name for all existing things or forms. And if there should be an existence it should be cognizable; and cognition can only be through one of the five senses, external or internal. In other words, there should be a sense-impression, either physical or mental, for every cognition. What corresponds to that sense impression is what is called 'form' or 'thing.' Form is not necessarily visual. It may be tangible, it may be audible, it may be smelt or it may be tasted, in some state of consciousness. Now, if by the Universe is meant the Universe of all such forms or things, 'we,' i.e., all things as above defined put together and standing interconnected, can alone be responsible for what we enjoy or suffer; for, there is no other to make us enjoy or suffer. If, however, we separate an entity, called 'God' or primordial matter, from the things in the Universe, then, either that God or that matter is responsible; or the things are responsible. There cannot be a joint responsibility between us things and the entity we came from, God or any other. Therefore, we must either resign ourselves to God, and blame or praise Him according as we suffer or enjoy; or, we must shoulder the entire responsibility ourselves. But Professor Lamb and all the idealists accept both a sovereign God and a sovereign matter, to control and guide our nature and activities; and at the same time, they order us, the controlled things, to be this and to be that, as if man is a free agent to do or not to do.

THEORIES OF ORIGIN FOR THE UNIVERSE EXAMINED.

After all, the theory that things must have had an origin—either creation (by God) out of nothing or unfolding or evolution from some pre-existing homogeneous matter—is largely one of speculation. Leaving aside the theory of creation and confining ourselves to the orthodox scientific theory known as the theory of evolution through natural selection, we find that it starts by assuming an undifferentiated or formless, inanimate substance, and regards animateness as a by-product of the evolutionary process. To the initial question whether animateness can ever come from inanimateness, no satisfying answer is vouchsafed. But this theory has been since modified so as to provide an animate agent from the very beginning. It is called the "theory of creative evolution." An intelligent First Cause—another name for God—is believed to guide the evolutionary process. Even Churchmen, especially of the modernist school, would gladly throw away, in favour of this new theory, the old Biblical theory of creation in six days as a comparatively recent affair—by way of compromise between religion and science. Others, while accepting this intelligent First Cause, would not credit Him with being able to do the guiding unaided. They would have a hierarchy to help Him in this evolution—guidance, though they do not seem to have explained whether this hierarchy is self-existent like God Himself, or was itself created or evolved, and if so how, by whom and from what material. But to none of them does the question seem to suggest itself, viz. if that intelligent First Cause is all that we consider God to be, omnipotent, omniscient, all merciful, why this slow, painful, and clumsy unfolding? Can He not do it by one effort? Again, why should He create one thing *out* of another, rather out of the *ruins* of another, which is what evolution, as ordinarily understand, means? Is it not a more understandable method to say that He made one thing first and then another and so on, i.e., unfolded himself successively into the various things in the Universe? Is this not better than to say that He made a bad or imperfect draft at first, in a hurry as it were, and has been endlessly erasing and improving it since? In any case, is it rational to suppose that an Intelligent Universe-maker, working singly or aided by a hierarchy, would have started his machinery before He had completed and perfected all its parts? Does Mr. Ford or any other motor maker, for instance, make delivery of an unfinished car, hoping to complete the construction while it is being driven? In fact, neither under the absolute monarchy of God, nor under his limited or constitutional monarchy aided by a hierarchy as aforesaid, nor again under a democracy, where God has no place, made up of the things of the Universe themselves acting as they like, could freedom from pain be expected, as long as those activities are indiscriminate and mutually destructive—just as, under the autocracy of old Russia or under the limited monarchy of present England or under the democracy of France or America, unrest and suffering do and must exist, as sure as the people living under no orderly arrangement, but at eternal war, direct or indirect.

Let us, therefore, not waste further time in speculating on the origin of things, but take them as they are; they will then unfold their own mystery. And what is the difficulty? If we can take some imaginary formless primordial matter, or Person, to be self-existent (or *anadi*), why can we not regard the formful Universe, made up of all things, as self-existent in their original prototypes, and all the subsequent changes as the result of their own mutual activities from time to time? In other words, if we can take *some* one thing, matter or person, to be our Creator, Preserver, and Destroyer, what is the difficulty in taking *all* things in their totality as their own creator, preserver and destroyer, in fact as the one and true God?

UNIVERSE, THE SELF-EXISTENT GOD.

Without discussing any further the conceptions of Godhead, we may safely say that it is the function of man so to arrange mutual activities as to make the Universe one integral, animate, mutually connected, mutually commanding whole. It *must* then become one eternal, omnipotent, all-knowing, unlimited thing. You may name that Thing God if you please, but it is really God, and has all the attributes associated with the Godhead. It *alone* has those attributes. For, as long as the unorganised state continues, there must be mutual limitations and untoward happenings. And so long will the question be asked, "if God were all-powerful and all-merciful, what is the excuse for all the ills in the world? Is it his want of power, or is it his want of mercy? It *must* be one of these two, or both. If there are any limitations on his power, he is not *the* all-powerful God. He may be more powerful than others, but cannot be *the* all-powerful God. If, on the other hand, he *had* all-power, but would not exercise it on behalf of those whom he claims as His creatures and His subjects, he is not all-merciful. In fact, he is very much *less* than a man. For, no average father with power to create and maintain absolutely evil-less children would omit to do so, and yet ask to be regarded as an affectionate parent. With an almighty divine father, the position must be much less understandable. Of course, I do not want to digress. But it is necessary to say so much in order to bring home the fact that the ordinary conception of an extra-cosmic God who is both all-powerful and all-merciful is absolutely inconsistent with a sinning and a suffering Universe.

THE FREE-WILL THEORY.

All this notwithstanding, religions may feel forced to posit an extracosmic God, i.e. a God other than the universe of things, on the ground that the universe *must* have a maker, though science, which agrees with religions in admitting a making, will make the universe its own maker. These religions may also assert His omnipotence and may explain away the inconsistency between the creator's omnipotence and the creature's imperfections by saying that when He made man, He gave free will to him, but, man, misused it and has therefore had to be punished. And some religions would add that God has been so far merciful to provide for the atonement of this offending by means of a vicarious sacrifice. But he that gave free-will must have known *how* his creature was going to use that free-will, and knowing it, he should not have given free-will to be misused, consistently with ordinary fairness, not to say fatherliness. If, however, he did not know what was going to happen, and if he is to plead like an ordinary parent who says, "I *did* give a revolver to my son and *did* give him the liberty to use it, but I did not bargain for his *misusing* it"—a plea quite like what Professor Lamb has put forward on behalf of science—God cannot claim any greater omniscience or all-mercy than that parent or this scientist.

THE ORIGIN OF EVIL, THE ONLY ORIGIN TO BE TRACED.

If, therefore, the universe of things, set to organismal working order, is God, and if no other can be that God, unlimited in all respects, the only origin that has to be traced is the origin of evil, i.e., the present non-God condition, or "evil" to use one word, and not the origin of God himself. Even the question why He, that great all-knowing and all-powerful God, reduced Himself to the present non-God condition need not be asked or answered. In fact, it cannot be answered under the existing limitations. It is sufficient to know, for all present purposes, *how* He descended, in order that we may know how He or we (both meaning the same) should *ascend*. We first posited separateness or space between the units of our great Cosmic Person, then gradually lost sight of the duty and responsibility of maintaining functional connection between the several units, and thereafter started a career of mutual antagonism and struggled with inequalities and limitations as the necessary consequence. Let us now retrace our steps, and our purpose is achieved. It may perhaps be asked, if the matter is so simple, how did the *idea* of enquiring into the origin of things ever come into the world at all ? To that question all that we need or can say is that, seeing individual units dying and being born, we generalised that the entire group of units, i.e. the universe, must have had a similar history, and following up this presumption, we sought the aid of Zoology, Geology and Paleantology to establish that generalization. No other explanation seems possible.

THE FUNCTION OF ANTHROPOLOGY AND INDIAN CASTE.

In this connection, a few observations regarding the unique institution of Indian sociology, viz., the caste system, may not be out of place. In fact, a paper on Anthropology at an Indian gathering, but with reference to the caste-system all omitted, may even be regarded as imperfect. What is caste ? Is it, as it indicates in Portuguese, a hereditary hierarchy of social divisions with mutual exclusiveness in the matter of touching, eating, marrying, and worshipping as the badge and outside symbol of that hierarchicalness, but without any identity of interest and consequent mutual responsibility ? If that is the caste *ideal*, it can only mean disunity and general inefficiency, and has no right to continue. It may have been for long the *actuality* more or less, and that was why the Westerner, when he first come to India, gave it the name " caste " ; and that is why India degenerated and became a subject country—economic, political, religious and intellectual. But is that the caste *ideal ?* If it is not, what is it ? So far as the system of caste implies a mere division of labour, nobody has a word of complaint to make. But when the benefits enjoyed by the members of one labour-division are not the same as, but higher or lower than, the benefits, enjoyed by another, and when this inequality is declared as part of the inevitable order of things, to be handed down from generation to generation, it is not a position that can be tolerated. Either, there must be equality of benefits ; or the hereditariness which means perpetuation of the inequality, must go. Equality of benefits is considered impracticable. All efforts therefore are directed to the destruction of this hereditariness and the obliteration of all divisions and differentiations. Of course, it is not claimed that social homogeneity will mean universal equality of benefits. But it is said that it will abolish privilege. It will give equal opportunities to all to *strive* for their separate individual advancement, opportunities for the stronger and fitter to win and possibility of the weak and unfit to lose—so that in the end, the fittest will survive, the unfit will go and the Darwinian law of progress will stand vindicated. That is considered a sufficient blessing to expect from the abolition of heterogeneity. And whoever stands to obstruct this process of homogeneification and this method of individual progress through unfettered competition, and advocates the ideal of heterogeneity and hereditariness, is regarded as a reactionary, as an obscurantist and as an enemy to society. This, of course, is right in a country where national life has been ensured and where the only need that exists is for keeping it increasingly fit to withstand outside competition and to even launch an active aggression against others. But in a country like India, where its native people have to live side by side with an highly organised and in all respects advantageously situated foreign people whose cult is competition and whose national polity is colonization and commercial expansion, institutions like caste, that knit people into one and keep them in their respective posts of duty, however unequally balanced their relation may be for the present, are extremely necessary and should be conserved at all costs. In such a country, the progressive self-destruction of its established hereditary order that is now taking place under the name of "progress" is merely the measure of its surrender to other nations and of its own advancing extinction. And is not all this a pity when the real caste ideal is the permanent organismal disposition of humanity with its nations, classes and sexes established in equally-balanced interdependence, and therefore the unerring key to universal Welfare ?

ANTI-UNTOUCHABILITY, AN UNSCIENTIFIC CAMPAIGN.

Mutual exclusiveness in social life of the various castes and sub-castes may perhaps be mistaken for inequality. But it is not inequality. It is but the inter-organic distinctiveness *necessary* for efficiency and harmony; and although, when found *associated* with inequality otherwise occasioned, it may, to the superficial looker-on, seem to be the badge of inequality and even its cause, no man of light or leading has any excuse for so understanding it, and thereupon, starting a campaign for the abolition of all distinctiveness, as they have been doing under the name of "removal of untouchability." It is not untouchability that must be removed. It is the inequality that must be removed; as for untouchability, it should, instead of being onesided, be made mutual and universal. If, on the other hand, it is only a question of abolishing untouchability, mutual or one-sided, it may be done by an effort of will of the people concerned. But that will not mean the abolition of inequality. Inequality will go only when equally-balanced interdependence is established. And that can only be through a policy of responsible patronage of each other's goods and services, an equal sense of necessity for each other's existence. This is quite possible. And until that is made possible, we must grin and bear all our present troubles. Else, we shall be thrown into increasing national chaos and ultimately swamped into annihilation in the international deluge. And I would add that if, in these circumstances, any body should fan the popular mind into revolt and into an agitation for conjuring up the semblance of equality, and if the dissatisfaction so created should increase faster than the intelligence and capacity for restoring social order and recreating true equality, rapidly increasing disintegration and still greater approximation to extinction can be the only results. Whoever undertakes such a mission may perhaps be the idol of the day. But he cannot be the idol of divinity, may-be of the reverse. We must remember that in every society under the sun, there is inequality. The king is superior to his people wherever he exists. When he does not exist with that name, he exists as an *unequal* authority, though under another name. The priest has held that superiority in some stage of the worlds' history. And so with all the other organs of the body politic, viz., industrial, commercial, etc. But this inequality, whether hereditary or non-hereditary, is a deviation from the normal, though it must be regarded as inevitable, as long as there is no organismal ideal in view. But with such an ideal and under the conception of all being parts of one interconnected whole, *equality* can be easily visualised, and inequality, where and when found, recognised as a sign of degeneration.

It may be pointed out to us that, even in the natural physical organism that we see before us, there is inequality between organs. There are the dominant and the subservient organs, the controlling head and the controlled limbs. In fact, organismalness is hierarchicalness; and such an ideal, applied to society, can only be the ideal of the reactionary and inequality-perpetuator, and not of the progressive man. But, as long as the universe itself remains in the unideal unequally-balanced condition, can any organism within it, physical, family, national or international, be an equally balanced one? Can one part in an interconnected whole attain an ideal condition in advance of the rest? It can only be a synchronous achievement along with that of others. Until then, hierarchicalness *has* to be tolerated, but of course so used as to ultimately bring about its extinction, just as real charity is to aim at its own extinction through the abolition of its need.

In any case, it is not mutual conflict but mutual concert that has been the cause of what good we have, either in the physical, national or international life. And all the evil is the result of reaction from the parts we have excluded from the orbit of mutually concerted existence. Let this be ever remembered. And let it be also remembered that an institution that has for its avowed object the linking of humanity so as to make one part feel that all other parts are its necessary complements and that it cannot live and satisfy its wants without the other parts, can alone serve in the great mission of universe-unification. It must be the indispensable first step. The establishment therefore of such an institution where it does not exist, and its reparation and restoration where it is lying in a state of disrepair, must be the primary concern of Anthropology, if its ultimate aim, as depicted *supra*, should materialise.

THE PROBLEM OF OVER-POPULATION.

But granting all this, it may be asked, "Can mutual conflict be *wholly* eliminated and that for *all* time, as long as population tends to increase in greater proportion than food-supply? Will it not necessarily lead to struggle at some stage or other?" Yes. But, under the canons of caste law which guarantee against trespasses by one sex on another, by one class on another and by one nation on another, all such struggles will be confined within the several compartments—sex, class or nation. They will not take the form, as it does now, of one sex competing with another sex, of one occupational class competing with another occupational class, or of one nation or territorial people travelling to and occupying the land of another. With competition and its consequent ills restricted in this manner, half the misery of the world must stop; and in this view and to the extent that miseries of sorts constitute the chief relaxer of self restraint and prompter of unrestricted sexual life and consequent multiplication of births, the question of over-population will get automatically solved.

A PROGRAMME FOR ANTHROPOLOGICAL WORKERS.

By way of a practical programme for Anthropological workers, I would suggest that we, straightaway and in a serious business-like manner, appeal to the world to make an unprejudiced examination of its activities. It will then be seen that they are all based on the principle that unfettered conflict sanctified by the name of "competition" or "struggle for existence" is the normal law of life. Let us first get the world to forswear that fatal principle finally and for good. Let us have installed mutual concert on the throne of the world's governance—concert through equally balanced and permanently rooted interdependence between sexes, between classes and between nations. Let us also note that these concerts are themselves interdependent. For the sex concert to become real, marriage must cease to be an optional institution, i.e. an institution of mere carnal necessity or convenient housekeeping. Else, responsible relationship between the sexes as the necessary organs of the family organism cannot be expected. And as long as this is so, there cannot be the need nor the possibility for division of labour with provision against mutual encroachment, on the lines that once obtained in full force and still obtains in some measure in India. And as long as inter-class strifes continue, the urge to trespass on other nations' lands and markets, and consequent inter-national wars, cannot be prevented, do what you will. This interdependence may be traced in the reverse order as well. This is, as long as there is no international peace, there can be no intranational peace, i.e. peace within a nation. And as long as there is no peace *within* a nation, i.e. between the families or rather communities of families, there can be no peace or settled order between the sexes of the family. And this dual interdependence may be taken up even *beyond* the human species, and exhibited as applicable to *all* the kingdoms of nature. *The only policy, therefore, of imperative universal necessity is to prevent mutual exploitation of all kinds and to promote mutual preservation in every possible manner, so as to make each sex feel that it will be incomplete without the other, to make each community of families feel that it will be incomplete without the other families, and to make each nation feel that it will be incomplete without the other nations, and eventually and in the long last, to make each kingdom of nature so alive and so animate as to feel that it will not be complete except in co-ordination with the other kingdoms—thus precluding the possibility of even the revolt of the elements in the form of floods and fires, earth-quakes and volcanoes.* In fact, man cannot deserve to be *Homo sapiens*, if he aims at anything less than making the universe *Natura sapiens.* On the other hand, to keep up inter-sex, inter-class and inter-national struggle in the name of freedom, commerce, or civilization, and yet to hope for peace either at home or abroad, is to rave, and not to reason. Let us in India, therefore, start a campaign for the promotion of established and equally-balanced commerce between sexes, classes and nations. Marriage for this purpose should become universal, so that every man and woman will have each an easily attained and difficultly alienated customer, and so that the family organism which is the root of the national tree could be reared and maintained on a solid foundation. In the same way, between the various groups of families or classes, exchange of services on terms of equality of benefit should be encouraged by the free buying of each other's services under a sense of duty and responsibility, and misled by no false imitation of other people's personalities which, bereft of any idea of self supply, must mean neglect of one's own territorial organism. And between all the nations of the world, coloured and colourless, there should be established a similar mutual dependence for some necessary commodity or service, so that it will be the interest of each nation to maintain the integrity and prosperity of all the others. The fruition of this inter-dependence-creating campaign will be the abolition of all mutual exploitation between sexes, families and nations. This is real organisation, or rather organismalisation work. Let us start it from the smallest populational unit, say the Indian village, and extend it until all the nations of mankind are made up into one inter-dependent organic whole. And let all our ethnological and ethnographic researches be used to suggest the best means, and to afford the most effective help, to that campaign. This is the tribute which old India, and Indian Anthropology in particular, should pay to the world.

As this is not the place for formulating a detailed scheme, I shall say nothing further. I shall content myself stating that, even though we may not be able *now* to visualize the extension of this organismalisation process, or process of *living* an absolutely unoffending life, to animals and plants, a state of no hunger and no eating, when alone can man's riddance from evil for which salvation is but another name, will be complete; and although we may *now* feel that we *must* stop with the human species in the matter of non-destruction and *must* accept the unavoidable destruction of plants and even animals for the satisfaction of our physical wants, is it a small achievement to have brought about the organisation of at least one entire species, namely man? Shall we not have thereby gained a *great* step in the redemption of the universe, and that in reason's full view and without relying on untranslatable imaginations, which is what poets and philosophers, prophets and moralists have asked us to do in the past and still ask us, leaving the world all the while a regular shambles, bloody and bloodless? For a long time of course, we workers in this line shall have to be ploughing a lonely furrow. It will take time for old errors to vanish. But if we go on with full confidence our gospel of truth will ultimately prevail, success *will* crown our efforts.

WHY WE ERRED IN THE PAST.

And why have we erred so long? We erred, because we failed to recognise the inexorable law of action and reaction. We failed to recognise that just as there is both animateness and inanimateness in *our* structure, which we call mind and body, or soul and body (including mind), there is both animateness and inanimateness in the universe as well. But we so far extended to her only our inanimateness, and not our animateness. The result was that we rode rough-shod over her without calculating the reaction. Thereby we disabled ourselves from solving many a problem of life. That is how we erred in the past. Let us now extend our animateness too to all things, weak and strong, ugly and beautiful (i.e. the entire universe), and count on her reacting on us just as we act on her, well or ill. Let us then see whether we are not better able to solve her varied mysteries.

And as for Anthropology, we have only been misusing it all along. We have regarded it either as a mere hobby, or as a hand-maid to the theory of progress through competition. It has even helped to give a scientific sanction to the inter-class and inter-national fights of to-day, to the struggles between the more civilized and less civilized peoples. To the vindication and practice of such a sinful principle, Anthropology should not devote all its life. Professor Haddon says in his Conway Lecture that in the conduct, control, and care of the less civilized races lies the practical value of Anthropology—by which he means the knowledge of their habits, beliefs, customs and manners. Let us sincerely hope that that conduct, control and care will be such as to enable them (the less civilized races) to grow and develop as self-respecting useful organs of the international organism, and not such as to create in them forces of blind imitation that must ultimately end in their extinction. For, such imitation of the personality of other people without the idea of self-supply would mean the breaking up of the bonds of mutual service by which every society is built up and maintained. And when nations, now in a position of vantage, not only encourage such imitation, but actively seek to *impose their* dress, *their* language, *their* religion, *their* customs and manners, etc., knowing or not knowing that it must disintegrate the unsuspecting people on whom the imposition is made, it is our duty, in the interests of universal welfare, to point out the mistake without fear or favour.

THE SUMMING UP.

Now let me summarize. The universe of things is an animate whole, continuous, connected and complete. It is further a self-existent universe. It is not the result of change from some other thing—all the changes now seen in respect of individual things—birth, growth, decay, death being due to adverse action between thing and thing. Let us further not commit the anthropocentric error of supposing that man is the centre of the universe and that all else is intended for him to subject or swallow: "Man for the universe and universe for man," let that be our motto. Let us note that we are in a monic universe, where all things are eternal, i.e. where no thing can be extinguished out of existence and where the fact of "change" which we call "death" is alone non-eternal, is alone extinguishable. Otherwise, neither *a priori* religions nor the *a posteriori* science can be of any great service to man. But. let not our monism be that species of monism which, positing matter and spirit as two separate entities, *derives* the one from the other. Let it be a monism in which the antithesis disappears—a monism which knows no matter without life and no life without form. In a certain state or condition or arrangement of that form or matter, it seems living and animate; in another, its life and animateness stand suspended. That is all. And this is a proposition which applies as much to the so called inorganic as to the organic world. For, do we not see the magnet that attracts iron filings, the powder that explodes, and steam that drives the locomotive? Are they not as much living as the sensitive Mimosa, or the venerable Amphioxus that buries itself in the sands of the seas, or the man when he thinks? And as for reason, "the spark of divinity in all things" taken in its wide sense, the monarchic bee and the republican ant have it just as most men, though, in the narrower sense of farsighted discrimination, it is as lacking in most men as in the majority of animals. Of course, man may nevertheless reserve to himself the title, *Homo Sapiens*, in the self complacent language of biological convention. But if he should honestly deserve that nomenclature, Anthropology must so regulate his activity as a physiological, domestic, social, national and international unit that his physical frame, his family, his class, his society, his nation and his kind may cooperate to the making up of an ideal cosmic organism where every part will live rid of all evil, in other words, to the attainment of collective, universal salvation. And only in so far as any research, be it called ethnological, ethnographical, anthropometrical. anthropographical, sociological, geological, palæntological, psychological, biological, in fact of any activity relating to man, directly and indirectly, helps this purpose, could that be reckoned as germane to the scope of Anthropology.

CONCLUDING REMARKS.

Ladies and gentlemen, in the remarks I have now addressed to you, I have essayed no poetry, attempted no rhetoric, but at the same time not hesitated to express straightly and bluntly what I consider to be true. I have done so in the belief that, in momentous questions and in a serious assembly of this kind, honest untimid statements, expressed in terms of cold reason, will alone be righteous. Mere idealism and pious wishes have no place in the stern economy of life. Just as I was finishing the draft of this address, I chanced to look into the appeal of our great countryman, Dr. Tagore, for peace and goodwill, published in *The World To-morrow* for November. I only wish to say that several great religious founders in the past, whose names I need not mention, have delivered such messages; but the world has remained the same battle-ground over which the flag of evil still flies. Our world-famed poet has made specific reference to the ills that weaker nations like India are now suffering; and he winds up by prophesying the time "when the names of the statesmen who tighten their noose round the necks of foreign races will be derided and the triumphant ark of skulls in memory of the war-lords will have crumbled into dust." Yes. The prophesy may prove true. But if there should be world preservation, there should be a positive recipe to it. No person wishes to kill another or to be killed by another. But still, homicides and suicides have marked the history of the human species. If therefore great visions should materialize, the way should be made clear. Mere seeing of visions without indicating the way, which it is what most prophets and idealists have done, is of no avail, and it is on that account that they have been dubbed as mere dreamers and visionaries. This should no longer be. In formulating for Anthropology the function it has to undertake in the economy of the world's life—the function of removing from it all unwelcome features finally and for good, which can only be by organising it, we must sketch out a rational plan on the model of Nature. And this is what I have endeavoured to do, though in bare outline. To quote from the Constitution of the Universal Welfare Association, of which I have the honour to be one of the promoters,

"When humanity now living under the sway of unregulated individual will shall have been *organised*, the other kingdoms of nature governed by immutable law will get automatically righted. All unfavourable reactions within the Universe, to which are due our present limitations in existence, knowledge and bliss, will then cease; and the reverse condition will take their place. In other words, the *Asat, Jada, Dukha* world, or *Jagat* as it is called in Sanskrit terminology, will have been transformed into the *sat, chit, Ananda,* condition of *Brahman,* transcending all limitations of time and space (or *Maya* to use the Sanskrit terminology again."

The Neo-Anthropologist is thus no visionary. He would march to his goal with a plan before him, through rational methods and by graduated stages—each stage being marked by a steady diminution of evil and a corresponding accession of good. To him, the uneventful carrying out of the programme and the unhindered attainment of the goal must be mere matters of course—the velocity of progress depending on the volume of effort. And if we believe that India's having outlived all the contemporary nations of antiquity is no accident, but the result of her deserving, let us, Indian anthropologists, investigate it without partiality or prejudice, understand the truth and be its emissaries to the world.

I shall now conclude. And I shall do so with a most reverent apology for the intrusion I have made on your valuable time and a heart-felt expression of gratitude for the phenomenal patience with which you have listened to me. "Seek in the broad places (of Jerusalem) if there be a *man,*" says the Bible; and He alone is the man who can use the "Science of Man" aright—*the standard of right being the Welfare of All.*

Abstracts of Papers.

1. Pre-historic man in India. Kurnool bone caves.—*By* L. A. CAMMIADE.

The profusion of paleolothic stations and the abundance of implements is proof that India was exceptionally well populated from the very earliest period of man's existence. This relative density of population is not surprising as according to most geologists, India enjoyed during the upper and lower paleolothic periods of Europe, a mild climate which did not differ essentially from that now prevailing. So far as is known, the Kurnool District in Madras is the only place in India, that furnishes a promising field for investigation. The fosiliferous caves though discovered about 80 years ago by Captain Newbold and in 1884 by Mr. Bruce Foote may now be conveniently explored as a Railway line, which did not exist then, now cuts the northern extremity of the limestone hills with three railway stations in close proximity to the caves themselves.

2. Evolution of dress and personal ornament.—*By* L. K. ANANTHA KRISHNA IYER.

Primitive man lived, at first in a state of nudity. He thought of painting and tattooing particularly those parts of the body which would lend themselves to decoration. He began to modify his shape by mutilations and deformations. Lastly he resorted to clothing, when painting and tattooing were gradually abandoned. Examples illustrative of the customs among people from all parts of the world. Tattooing, its origin, development and practice. Explanations of the practice. Clothing; the chief varieties of clothing of primitive man.

3. Institution of Deva-dasis in South India. Traditional origin and development.—*By* L. K. ANANTHA KRISHNA IYER.

The origin of the Custom. Its prevalence. Ethnological significance of the custom. Origin of Basavis; its prevalence. Difference between the two customs.

4. Racial types in India.—*By* L. K. ANANTHA KRISHNA IYER.

5. Left and right hand sects in South India.—*By* L. K. ANANTHA KRISHNA IYER.

Left and Right hand Sects in South India. The divisions peculiar to South India. Origin and development. Constant disputes between the members of the two groups for social superiority. Court decisions.

6. The duties of Desa Setti.—*By* L. K. ANANTHA KRISHNA IYER.

A prominent man in the village organization. His privileges. His decisions on caste disputes.

7. Anthropometric Survey of India.—*By* P. C. MAHALANOBIS.

8. The light of Indian literature on communal antiquities in South India.—*By* K. S. Rama Swami Shastri.

1. The incubus of the assumptions and assertions of western scholarship.
2. What is Dravida and what is Tamil ?
3. Rival theories about the origins of the Tamil people.
4. The light thrown on communal origins in South India by the ancient Tamil classics.
5. The significance of certain South Indian traditions.
6. The twisting of the Ramayana. Who are Rakshasas ?
7. The unity of the Indian people.
8. Conclusion.

9. Asurs, ancient and modern.—*By* Sarat Chandra Roy.

In this paper the author gives an account of the habitant, physical features and general characteristics, dress and ornaments, occupation, domestic life, social organization, religion, and other customs and institutions of the Asurs who are a small but interesting tribe of iron-smelters dwelling on the jungles and hills in the extreme west of the Ranchi District. He next refers to the traditions current among this tribe and also among other tribes of Chota-Nagpur about an ancient people of the same name and the prehistoric remains traditionally connected with them, and discusses their probable affinities with the existing races in and outside India.

10. Law of Jubilee.—*By* R. B. Hiralal.

Shows the nature of the Law of Jubilee and cites a case which cropped up in the Bilaspur District of the Central Provinces, with a relic of the same custom found in that country. Invites further investigation into the matter.

11. Two recent instances of exorcism from Southern and Eastern Bengal.—*By* Sarat Chandra Mitra.

Primitive men believe that diseases can be cured if the spirits which cause them, can be expelled or exorcised away. There is a certain class of professional men among them who are believed to be well up in the arts of sorcery and charming. They believe that it is they who by means of their charms and spells, can drive away the disease-demons or disease-spirits.

Traces of this animistic belief still survive among the womenfolk of the countryside in Southern Bengal. These women believe that diseases are caused not by the violation of the laws of health but by the mischievous propensities of invisible spirits who are hovering about in the air. These spirits are under the control of the goddess Kali who lets them loose to torment a particular person who might have offended her deityship. If the goddess can be propitiated by suitable sacrifices and offerings, by appropriate prayers and incantation, she can be so far placated as to withdraw her myrmidons—the disease-demon—and thereby free the offending patients who have offended her.

A recent instance which illustrates in a remarkable manner, the prevalence of the afore-mentioned belief among the ignorant womenfolk of Southern Bengal occurred sometime ago in a village in the district of Howrah.

A detailed description of the rites connected with this case of disease-exorcism has been given, and the significance thereof has been discussed in this paper.

Ghosts are also expelled by the performance of the rite of exorcism.

A case recently occurred in the Munshiganj Sub-division in the district of Dacca in Eastern Bengal, wherein a person who was believed to be possessed by a ghost, was repeatedly plunged into the water of the tank under the belief that the ghost possessing him, would be expelled or exorcised away. But it turned out that on account of the repeated ducking which the possessed person had to undergo, he died. The persons who ducked the possessed person have been arrested and sent up for trial on a charge of manslaughter before the Sub-deputy Magistrate of Munshiganj.

It is popularly believed that witches and spirits cannot cross running-water. This idea has originated from the primitive belief that the souls of deceased persons have to undergo great difficulty in crossing rivers while on their way to the other world.

The author thinks that the illiterate villagers of the Munshiganj Subdivision superstitiously believe that ghosts and other malignant spirits have an antipathy to water and cannot endure being plunged therein. They, therefore, repeatedly duck the person whom they suppose to be possessed by a ghost in the water of the tank so that the ghost might leave him.

12. On a far-travelled Star-myth.—*By* SARAT CHANDRA MITRA.

In this paper, the author has discussed Santali, a Munda and a Malay aboriginal Star-myths which are very similar to each other. As a result of his discussion thereof he has brought out the following noteworthy features of these folktales.

1. In the Santali-myth, the sun and the moon are related to each other as husband and wife, in the Munda legend they are sisters, and in the Malay aboriginal myth the sun is a male and the moon a female, but the relationship between the two is not stated.

2. In all the three Star-myths, the stars are stated to be children of the sun and the moon.

3. In the Santali and the Malaya myths, the moon plays a deceptive trick upon the sun and persuades the latter to devour his own children the stars. But in the Munda legend, the moon kills the stars who are the children of her sister the sun, and, by telling a false story deceives the latter into eating a portion of the flesh of her own children.

4. In all the three star-myths, the stars together with their father (or mother ?), the sun, are stated to be very hot and scorching and between themselves made the earth uninhabitable for living beings and would not allow any vegetation to grow. In order that the earth might become suitable for the habitation of mankind and for the growth of vegetation, the moon killed the stars.

Star-Myth.

In the Santali and the Munda legend, it is stated that when the sun discovered the treachery that had been committed by the moon he (or she) attacked the latter and cut her in twain. This is the reason why the moon waxes and wanes every month. In the Malay myth it is stated that when the sun came to know of the Moon's act of treachery and murder, he became angry with her. For this reason, whenever the sun meets with the Moon, he fights with the latter in order to wreak vengeance upon her. This is the reason why the lunar eclipse takes place.

6. In the Santali and the Munda legends it is stated that the Moon hides her children (the stars) during the day-time, because she fears that if the sun who rises at daybreak, would catch a glimpse of her children, he would kill the latter. This is the reason why no stars appear and shine in the sky during the day-time.

The author is of opinion that the Santals, the Mundas and the aboriginies of the Malay Peninsula have not borrowed these Star-myths from each other. He has explained their similarity by Franz Boas's theory of the parallelism of culture development.

13. The Cockroach's relatives. A study in comparative Storiology.—*By* SARAT CHANDRA MITRA.

In this paper, the author, has discussed from the storiologist's point of view a Bengali folktale and its Santali variant which illustrate the truth of the English proverb that. " It is a dirty bird that fouls its own nest" and which inculcates the lesson that no one should belittle or express contempt for his own family, caste or tribe.

Although there is a strong similarity between the two stories, the author thinks that they have been evolved independently of each other, for the following reasons :—

(1) The leading characters of the bengali version are the cockroaches ; whereas those of the Santali variant are human beings who are no other than the members of the Musahar tribe.

(2) The minor characters of the two stories are also quite different.

(3) The style and language of the two versions are also quite different.

14. On two recent instances of self-mutilation for propitiating a goddess and a god.—*By* SARAT CHANDRA MITRA.

A simple offering has been defined to be anything which is devoted to the service of a deity. It may be either an altar, a slave, a garment or a jewel. It may also include either blood from the body of a devotee or any of his limbs such as the head or the hand or the tips of the tongue after it has been lopped off from his body.

In these last cases, the offering takes the form of mutilation of his own body by the devotee. In this paper the author, has described and discussed two cases of self-mutilation which have recently occurred in Northern and Western India. In the first case, the devotee cut off the tip of his tongue on the 10th August, 1925, and presented the cut off tip as an offering to the goddess Tapeswari at Cawnpur. In the second case, the devotee cut off his own head on the 24th August, 1925, and presented it as an offering to the God Siva in the village named Takarguda near Junagada in Kathiwara.

15. On a Bengali magical rite for the prevention of apprehended hydrophobia.—*By* SARAT CHANDRA MITRA.

In this paper, the author describes the performance of a Bengali magical rite for the prevention of apprehended hydrophobia, which he witnessed on the 27th August, 1925, in Calcutta. In the course of this rite, the Bengali medicine-man or Ojha feeds the person bitten by the dog with a lump of charmed molasses. Then he fixes a charmed bell-metal platter (Thala) to the patient's back. If the virus of the dog-bite remains in the patient's body, the platter sticks to his back. Otherwise it falls off from his body. Then the patient is made to stand upon a spherical-bottomed earthenware saucer on the exterior of which, *mantras* in Bengali character are written with white chalk. Under the influence of the mantras, recited by Ojha, the saucer revolves automatically with the patient standing therein. When the virus leaves the patient's body, the earthenware saucer gets broken to bits. The author thinks that there may be a sub-stratum of truth in the Bengali medicine-man's statement that the earthenware saucer revolves automatically under the influence of incantations recited by him.

16. On two more Santali folktales of Der Mann and Fuchs' type.—*By* Sarat Chandra Mitra.

The author discusses in this paper two Santali variants of the folk-tales known as belonging to the 'Mann and Fuchs' type. 103 variants of this type, had been previously studied and discussed by the author. Thus the total number of these folk-tales has been brought up to 105, all of which are current in different parts of the world.

There is a good deal of similarity between these 105 variants, which the author explains by Boas's theory of parallelism of Culture development.

17. On two aetiological myths about the Paddy-Birds' long neck and legs.—*By* Sarat Chandra Mitra.

The Pond Heron (*Ardeola grayi* Sykes) is a very well-known bird of the Indian countryside. It is found most abundantly everywhere in India. It is known to the Europeans in India as the Paddy-bird. The most remarkable physical characteristics of the Paddy-bird are its long curved neck and stilt-like legs. These bodily peculiarities attracted the notice of the most thoughtful observers among the two primitive people—the Santals and the Mundas. Being unable to find out the true biological causes of the origin of these peculiarities they invented two aetiological myths to account for their origin.

In the Santali folk-tale, the Paddy-bird, at the request of the heroine, undertakes to impede the path of her pursuer. The latter having come to know of this, seized the bird and gave its neck a strong jerk, whereupon the bird's neck became long and shaped like the letter "S".

But in the Munda myth the Paddy-bird expressed its inability to furnish the hero with information about the heroine's whereabouts. This enraged the hero who, placing his feet upon the bird's legs, stretched out the bird's neck which thereupon became long and slim like that of a snake, and its legs became stilt-like.

In both cases, the punishment of the Paddy-bird by a person who got enraged with it, is the root cause of its peculiar bodily features, namely its long and slim neck and stilt-like legs.

18. Note on a taboo forbidding the son-in-law to meet or touch his mother-in-law.—*By* Sarat Chandra Mitra.

In this paper, the author mentions the prevalence, among the Hindus of Chittagong in Eastern Bengal, of the curious taboo which prohibits the son-in-law to meet or touch the mother-in-law, and says that this ceremonial prohibition is also prevalent among the Pueblo-Indians of North America. The parallelism between the two taboos, prevailing amongst these two widely separated peoples is a very remarkable one. He further says, that this taboo has been evolved amongst these two peoples independently of each other. He explains their similarity by Boas's theory of the parallelism of culture development.

19. Mustard in magic and religion.—*By* Kalipada Mitra.

20. Some interesting points in the marriage customs of Bihar.—*By* Kalipada Mitra.

21. Levirate marriage in Ramayan.—*By* H. C. Das-Gupta.

Reference is made to a few lines in the *Aranyakandam* of Ramayana and the author is of opinion that these can be best explained on the assumption that the ancestors of Ram practised the levirate form of marriage in the remote past.

22. A few types of sedentary games prevalent in the Punjab. —*By* HEM CH. DAS-GUPTA.

In this note the author describes a few types of sedentary games prevalent in the district of Mianwali in the Punjab. The games dealt with are—*do-guti, tre-guti, nao-guti, shera bakar, ratti-chitti-bakri* and *khutka boia.*

23. Pulappeddi and Mannappedi in S. Travancore.—*By* A. S. RAMANTHA AYYAR.

This short paper deals with a peculiar social right which the Pulaiyas and Mannars, two of the polluting castes of S. Travancore, enjoyed in the month of Karkataka of throwing a stone on an unescorted woman of a higher caste and of polluting her thereby. Virakeralavarman, a Travancore king of the end of the 17th century A.D., issued an order to the villagers of Tiruvidangodu that these practices be stopped. This royal mandate dated in A.D. 1696 is found engraved on the four faces of a stone pillar, set up in the roadside in that village.

24. The Mermaid Myth.—*By* S. T. MOSES.

Mermaids and their different kinds—Dragon of the Philistines, Sirena, Nereids, Naiads, Hydriads and Tritons of the classics, "Kadalmathus" and 'Kiraders' of Ramayana—Mermaids and Rama at Danushkodi—Local explanation of the 'Redwater' phenomenon on the Tinnevelly and Ramnad coasts—Dugong the supposed original of the mermaid—Its habits peculiarly human—Its tears.

25. The "Phantom ship" in the Arabian Sea.—*By* S. T. MOSES.

The "Phantom ship"—origin of the belief—The Flying Dutchman—Captain Marryat's "the Phantom ship"—Sir Walter Scott and the Demon-frigate—Places where the belief is current—Its echoes in South India—Laccadives, Maldives and Velliyan Kallu off Malabar.

26. Crocodile and its sanctity in South India.—*By* S. T. MOSES.

Crocodile and Leviathan of the Scriptures—sacred to Egyptians—vehicle of Niridhi—its diet—monkey's liver and crocodile in the Panchatantra—Man-eating propensities—Crocodile tears—Sankarachariya and a crocodile—Mahadeva bitten by a crocodile—The exemption of Valluvars—Crocodiles and 'trial by ordeal' in Kerala—Sacred crocodiles if harmed bring about *cecility*—other crocodiles are eaten by certain castes—sacred crocodiles at Pommala, Palliport—Triprayar and Madai.

27. The Hill-Pandarams of Travancore.—*By* L. A. KRISHNA IYER.

The Hill-Pandarams are a hill-tribe found in the Koni and Achinrcoil forests of Central Travancore. They are one of the few tribes of South India in a state of savagery, subsisting by hunting and collecting forest produce. They represent one of the least modified survivals of the ancient Pre-Dravidian race. They live in rock-shelters or small-huts, and leave them in favour of others, when their food resources are exhausted.

Marriage takes place both before and after puberty. Child-betrothals are common. Marriage takes place between cross-cousins.

The dead are buried where they die. After burial, they do not visit the locality in after years. Sons succeed to the patria potestas on their father's death. They are fast disappearing, and it may not be very long before they become totally extinct.

28. The future of Anthropology.—*By* S. SIVARAMKRISHNA IYER.

Anthropology is the science of the evolution of man. The highest stage in man's evolution is limitlessness in space and time. And this can be secured—though at some distant far-off date—only through the establishment of right functional connection, for which Caste is but another name.

29. The Polias, Babupolias, Paliyas or Rajbansis. An instance of the "conversion of tribes into castes" in Bengal.—*By* D. N. MAJUMDAR.

Polias, Babupolias, Paliyas, or Rajbansis are the different appellations by which the tribal population of Dinajpur, Rungpur, Jalpaiguri and Coochbehar are known. They are probably of the same stock. The word 'Polia' is according to the avowal of the people themselves, a variant of the Sanscrit 'पलातक' which means runaways. They call themselves Bhanga-Kshatriyas and wear the sacred thread in support of their claim. The Babupolias are lower in the estimation of the Polias for the former have not taken up the sacred thread and have not given up pig-eating. Of course, there are Babupolias who are being converted into Polias by virtue of their adopting the sacred thread and abstention from animal diet. The Polias call themselves Rajbansis or descendants of the Kshatriyas who were the ruling chiefs of India, often claiming descent from Dasaratha, king of Ajodhya. The physical features of the Polias add weight to the suggestion that they are a Mongoloid tribe in the process of forming a new caste. The author discusses the processes by which this transformation is being carried on and draws the attention of Indian Anthropologists to study the processes involved, in right earnest, and record the manners, customs and traditions of these people which are rapidly becoming obsolete.

30. The Kinship terms of the Polias, Babupolias and Rajbansis of North Bengal.—*By* D. N. MAJUMDAR.

The author gives in detail the Kinship terms of the Polias and compares them with those of the Santhals, the Hindus and the Mohammedans who are their neighbours. Attempt has been made to explain the significance of the use of some terms which owe their origin to cultural contact and borrowing.

31. A few types of dramatic and sedentary games of the Hos of Kolhan in Singbhum.—*By* D. N. MAJUMDAR.

As many as 16 games of the Hos have been described in detail (1) Chhur, (2) Sekar, (3) Kanju, (4) Kasa, (5) hotadanda, (6) tukaodanda, (7) gacha, (8) kulaochal, (9) landapati, (10) maliinum in water, (11) maliinum on land, (12) kuidinum, (13) tir, (14) gaigaiinum, (15) baga, (16) cock fight. Some of these games, if not all are also played by the Mundas, the Santhals, the Birhors, the Tamarias, the Kharia mundas and other sections of the Kolhan race. The most interesting sedentary game is the 'kulaochal' which is played in every part of India. The diagram used by the Hos is a simple one. The units or 'gutis' as they are called are 24 in number of which 4 are 'kulaos' or tigers and 20 called 'marams' or goats. One party takes the tigers, the other party the 'marams' and the duty of the latter is to defend the 'marams' against the depredations of the tigers.

32. Marriage customs of the Hos of Kolhan.—*By* D. N. MAJUMDAR.

In this paper the author describes in detail the various forms of marriage in vogue amongst the Hos of Singbhum, (1) andi, (2) dikkuandi, (3) apartipi-andi, (4) anader, (5) heromchetan andi, (6) Sangaandi, (7) marrying the younger sister of the wife after the latters' death, etc. The omens, which determine the marriage are given, marriage laws, divorces, etc., are discussed in detail.

33. Ho beliefs about disease, death and after.—*By* D. N MAJUMDAR.

In this paper, the author describes in detail the beliefs ot the Hos regarding disease, death and after. The influence of spirits or 'bongas' on the lives of the Hos is believed to be so great that the Hos attribute all disease and death to the mischief done by the 'bongas.' Natural deaths in a hunting tribe are very rare, deaths being mostly due to accidents. Although the Hos have mostly settled down as agriculturists, the outdoor life led by them naturally involves many accidents and deaths from natural decay are seldom met with. Again, having no idea of the maximum period a man may live on earth, even natural decay is attributed by them to causes external to the body and influenced by the pleasure or displeasure or the 'bongas' who are on the lookout for men's defects. After a brief analysis of the beliefs of the people the author proceeds to give an ethnographic description of all the customs and practices attended to during disease, death and funeral.

34. Ethnographic notes on the ideas about eclipses, excommunication, adoption, rainmaking, hoarfrosts, and hailstones, dreams, earthquakes, etc. of the Hos.—*By* D. N. MAJUMDAR.

The author briefly describes the beliefs of the people about eclipses, excommunication adoption, rainmaking, hoarfrosts, and hailstorms, dreams, earthquakes, etc., and compares them with similar beliefs found among the other sections of the Kolan race.

35. Ho life in Ho riddles.—*By* D. N. MAJUMDAR.

Some of the riddles of the Hos are given and discussed—They reflect light on the mentality of the people composing them—Many of the riddles are found to be in vogue amongst the Mundas and the Santhals which testify to the unity of the Kolhan race.

36. The comparative Anthropometry of the Indian Castes and Tribes.—*By* B. S. GUHA.

The chief anatomical characters of the important castes and tribes of India and Burma have been biometrically considered by means of a formula suggested by Karl Pearson and known as the Co-efficient of Racial Likeness. The analysis shows first of all the existence of considerable difference between individuals belonging to the so called upper and lower castes but considered regionally marked similarity is observed within definite zones irrespective of all caste considerations. Secondly three main ethnic groups are found who appear to have moved from their main centres of concentration viz., two from the Northwest, along the Gangetic valley and Western borderland and one from the North-Eastern frontier region along the Brahmaputra River, while a fourth—an autochthonous element—is present throughout the country in varying proportion.

37. A note on dancing and its significance among primitive tribes.—*By* L. K. ANANTHAKRISHNA IYER.

Among primitive men, dances were all of a sacred character. Propitiation of the supernatural powers to bless them with rich harvest. A closer contact with them, for help of all kinds Dancing in imitation of the movements of birds and animals. The abodes of the unseen gods. Dances in front of them in groves and sacred places. Varieties of dances. Songs with the aid of musical instruments as essential accompaniments. Present modes being an evolution of the old types. Conclusion.

Section of Psychology.

President:—H. D. BHATTACHARYYA, M.A., B.L. P.R.S.

Presidential Address.

THE PSYCHOLOGIST AND HIS SCIENCE.

Ladies and Gentlemen,

I feel myself highly honoured by being called upon to preside over the deliberations of the Psychological Section so soon after its foundation. Quite in the fitness of things, my predecessor in this office was Dr. N. N. Sen Gupta, who had the honour of starting the first regular Psychological Laboratory in India. I simply carried the torch I lighted at Calcutta, to Dacca which now claims to have the second Laboratory in India. I have no doubt that in the near future it will be recognised all over India, as it has already been recognised in many countries of the West, that for the proper study of Psychology, as for the study of Physics and Chemistry, a Laboratory is an indispensable adjunct in every College and every University.

While we are discussing the spread of this new branch of learning, let us not forget to pay our tribute of respect to the memory of Sir Asutosh Mookerji, to whom we owe not only the founding of the first laboratory of Experimental Psychology in India but also the starting of this Psychology Section. Before he came forward to champion the cause of this science, the voices of Dr. Sen Gupta and myself were as voices in the wilderness. We were offered by the authorities of the Congress a half-section and asked to combine with Anthropology to form one section, as Physics and Mathematics are still doing. But we had more faith in the importance of our subject and we did not want to embarrass either the anthropologists or ourselves by this unnatural alliance. It is just likely that our training in philosophy made us draw a clear distinction between Anthropology and Psychology, as has been done, for instance, by Hegel in his Philosophy of the Spirit, and the very generous response we received last year from all over India to our late invitation for papers confirmed us in the belief that this section would not at any time languish for want of materials. It is up to you now to feed this section, year after year, so that it might not be said that the science we profess has no devout votaries in considerable numbers and should not have been granted an independent section in the Congress.

But while we complain against the temporary injustice done to our science we must not forget that the British Association, on which model this Science Congress is founded, took a much longer time to recognise the claims of Psychology and Education. We may congratulate ourselves that we had less trouble than our fellow-workers in the West to get into the Science Congress. The psychologist is indeed in a difficult predicament nowadays. He is now an outcaste among philosophers for daring to deny that the science of mind is primarily meant to strengthen a belief in the substantiality and eternity of the soul. The rationalistic approach is no longer an article of faith with any psychologist as such, although it is open to him to have a philosophy in addition to a psychology, as the cases of Wundt, Münsterberg, McDougall, Ward and others show. It is the phenomenology of the mind that is his primary concern, and, as such, his method of approach is identical with that of the natural scientist, although the materials are of a new order and the instrument of exploration is different. It would have been illogical indeed if the scientists had refused to bring psychology within the folds of natural science. From the time of Greek speculation onwards the materialists (who championed the cause of natural science) had been telling us that mind was of the same order as matter. La Mettrie, Holbach, Vogt, Spencer and a whole host of them reiterated that mind was of the same order as life and that life was evolved out of matter. What prevents then the scientist to acclaim the psychologist as his kinsman? It must be admitted therefore that, inspite of their faith that matter and energy are the root of all creation, the scientists have not been able to get entirely over the vague feeling that probably mind is something different from matter and that with such an impalpable being it is better not to have anything to do. And they have hitherto been fortified in this belief by the fact that the psychologists of the past were also philosophers, and, naturally, where speculation reigns supreme, observation and experiment have no place. The new school of psychologists that has arisen can, however, claim that it has nothing to do with speculation or philosophy, and that it studies mind much in the same way as the natural scientist studies matter. I do not want to go into the vexed question of the necessity of alliance between Philosophy and Psychology, for what I might say would probably be in favour of the alliance, and then I would be accused of a bias in favour of philosophy in which I had the major part of my training. It is almost certain that future Presidents of this section will be less philosophically inclined than my predecessor and myself, whom a Calcutta paper once felicitously described as the missing links between philosophy and psychology. Perhaps it would be for the benefit of psychology as a science that its workers should possess as little as possible of the speculative tendency. But before psychology takes final leave of philosophy, let it acknowledge with gratitude that Introspective Psychology owes a heavy debt to philosophers for all that they did to spread its domain among the laity and the professionals alike.

But while it is easy to say that psychology is not philosophy, it is more difficult to say exactly what it is. To say that it is the science of mind is not to solve the problem at all, till we know what mind is. Did not the rationalists think that mind and soul were closely related entities? In the hands of Hume and latter-day psychologists, mind was limited to the states and processes of thinking without reference to any underlying principle. Modern psychologists have gone beyond this standpoint in two ways. We have now a new conception of mind, according to which the unconscious plays a great part in the determination of conscious attitudes. We have now advanced a good deal beyond the theories of mind-stuff as advocated by Spencer and Clifford or the theory of apperception-mass as advocated by Herbart. The atomistic conceptions are as surely out of place nowadays in the realm of mind as they are in the realm of matter. We are now in search of a dynamic principle of thought and are trying to discover whether, after all, mind could not be defined in terms of reaction to natural and social surroundings. The biologists, beginning with Spencer, raised the question as to whether mind could not be regarded as the prolongation of vital reaction, and now the Neo-realists in Philosophy and the Behaviourists in Psychology are joining the older Instrumentalists like Dewey and the neo-vitalists like Bergson in the view that mind is only a cross-section of reality and understandable only as a mode of reaction of the organism to its complex situations. These thinkers do not go so far as the older materialists who regarded the brain as secreting thought just as the liver secretes bile; but there is at the same time a definitely outward-directed look in explaining mental phenomena. This changed attitude is probably a reaction against the extravagance of introspective analysis to which older psychology confined itself; it may also be due to a greater knowledge of the potentialities of life, which an increased acquaintance with vital phenomena has brought about. The doctrine of Evolution which, inspite of a few reactionaries, is the creed of the majority of philosophers and scientists, refused to treat the mind as an entirely novel creation, and even though Wallace continued the Cartesian tradition of a rational soul, the trend of Darwinism was to deny that nature created the lungs but God created the brain. Comparative psychology again tried to establish the similarity between human and animal reactions in many matters and tended to reduce their popularly accepted distinction in kind to a distinction in degree only. In other words, the description of man as slightly lower than angels was changed to that of man as a glorified animal.

Meanwhile philosophy had been preparing the way for a changed outlook. The old Aristotelian Logic had been defining man as a rational animal. The Churchmen were interested in the rational aspect and told people that man was distinguished from other animals by his rational behaviour in all matters,—that while animals were guided by instinct, man was guided by reason. Even when the dualism of body and mind obtruded itself uncomfortably upon men's attention, a compromise was effected by saying that while the body of man was a machine his mind was a spark from divinity and, as such, he must render unto Caesar what was Caesar's and unto God what was God's. Theories had to be propounded as to how such a household divided against itself could stand, and various speculations were advanced as to how the soul and the body were related and how they could come into relation with each other. Materialism, Dualism, Spiritualism, Panpsychism and a host of similar creeds were put forward as solutions of this vexed problem. While such was the situation in the philosophical world, the psychologists thought it wise to ignore speculations altogether and quietly pursue a positive study of mental facts.

The rise of the Association School in England is therefore of such historical importance in the development of Psychology. The tradition of empiricism in British Philosophy kept speculation within proper bounds and Hamilton, Brown, James Mill, John Stuart Mill, Bain and Spencer carried on the work of Hartley and Priestley according to their own light and did not allow Psychology to be clogged by too much philosophical speculation. These writers, whether as philosophers or as psychologists, gave excellent analyses of mental facts, and even though the current psychology has travelled far away from the standpoint of these writers, the days of Analytic Psychology are not entirely over, as the work of Stout shows. It is not in respect of the data that modern psychology differs from older psychology—it is the method of interpretation that has profoundly varied. Modern writers have discovered more profound associations than those discussed by Association Psychology and have attempted to solve more satisfactorily the preferential groupings of mental elements in individual lives. Associationism again was born under the influence of Idealistic traditions; but modern psychology has had the advantage of being backed by a Realistic revival in philosophy. In the new dispensation of things equal justice has been sought to be done to both mind and matter. Wundt, James, Holt, Russell, Alexander and, in fact, almost all Realistic writers of note have attempted to do justice to Matter in their theory of reality with the effect that Consciousness is no longer regarded as having any prerogative position in reality. The development of the concept of Mind is as much a problem as the development of the idea of Matter. We no longer take Mind for granted in psychology. Biology has insisted from the very beginning that

Mind should be regarded as a problem and now Realism has seconded the demand. So the task of the psychologist has enormously increased and the complacent occupation of self-analysis without reference to the biological background of mind has come to an end. It is no longer possible to be a good psychologist without being tolerably acquainted with broad biological and physiological facts.

If any other point in this connection needs notice, it is the rise of individualistic psychology. Ward had indeed described the standpoint of psychology as individualistic; but when he wrote, the word had an entirely different connotation. By 'individualistic' Ward meant to convey the fact that only one mind was accessible to direct observation, namely, the mind of the introspecting subject. All other minds were indirectly known, viz. by interpreting the bodily signs of those others on the analogy of our own expressions. By 'expressions' at that time were meant the broad visible features of bodily movements,—the flush of face in anger and shame, the shaking of the body in rage and terror and such other phenomena which did not require any delicate instrument to detect and measure. It was the surface excitations that were then considered as the only indices open to observation and the only data available for constructing an idea of other minds. The New Psychology has not abandoned the salutory check which these introspective psychologists imposed on their speculation regarding other minds and has not bidden for the honour of being the science of psychical research as well. The body is still the medium of communication between mind and mind; but if one wants to appraise the distinction of the old and the new, one need only read the works of Spencer and Cannon on the Language of the Emotions to have an idea of the development of our knowledge regarding the bodily concomitants of mental states. Our instruments for detecting the number and amount of bodily changes are gradually becoming more and more refined. The automatograph, the cardiograph, the pneumograph, the sphygmograph and the plethysmograph, which were the pride of the age just over, are being slowly replaced by other instruments which are meant to gauge the chemical changes in the body in different states of the mind, specially of an affective kind. The dubious significance of bodily expressions is being confined within gradually decreasing limits, and slowly the data are being taken out of the control of the subject and put on an objective basis. Simulation is rendered more and more difficult as subtle bodily changes are made the bases of interpretation. Incidentally, it is being proved that, inspite of its ethereal nature, the mind is not without its feet of clay and that it is within the competence of the psychologist to diagnose mind by noting the subtle changes that the body undergoes during thought. Behaviourism may be extravagant in its claims, but it has put the finger on the right spot in its diagnosis of mind.

I am treating this point at some length for it is not generally admitted by the psychologists of the older school that the body is at the root of mind in a more real sense that they imagine. This refusal partially arose no doubt from an ignorance of the potentialities of the body itself. With a few notable exceptions, most of the psychologists had a vague general idea that the brain was the seat of the mind (if mind had any seat at all), that the size and number of convolutions of the brain had something to do with intelligence, and that the evolution of higher forms was attended by the growth of a more complex nervous system. Latterly, phrenology introduced a fantastic theory of localisation, and when this pseudo-science was dethroned the localisation of simple functions was as rigidly conceived for some time and retarded the growth of our knowledge of the possibilities of the bodily organism. The fact is that anthropology and comparative physiology had a tendency to over-emphasise the broad distinctions of anatomical and biological features. It is when inter-specific distinctions are noted in respect of men that the finer shades of difference come into view; and in order to study the potentialities of the organism the same body is to be examined in its various forms of existence at different times. For this, clinical materials are wanted and also a deeper knowledge of the body than what the older physiologists and psychologists possessed. The anthropologists whom they could consult, could only tell them that there were typical distinctions between race and race, between the Bushman and the Caucasian; but when it came to explanation they had no satisfactory theory to offer. Even now prehistoric brains are being excavated and their cranial features religiously noted and their cephalic indices measured; but we are almost as far from any satisfactory explanation as before. This mystery of human development, though less profound than the mystery of the evolution of species, is standing in the way of a more comprehensive knowledge of the origin of mental functions and of the development of intelligence in general. But there is the outstanding fact that, in the struggle for existence, the more primitive races, inspite of artificial care bestowed on their preservation, are being gradually exterminated because they fail to adjust themselves to the changed social surroundings for which they have not the adequate organic outfit and are not developing any. What is at the root of this mental inability of the savage? The negro, whose chromosomal constitution is perhaps different from that of most other races, has shown his capacity to orient himself to the altered conditions of life; but the primitive inhabitants of Ceylon and the Andamans are unable to come up to the minimum requirements of modern life and are dying out. What is at the root of this—the body or the mind? It is as much a problem for psychologists as for anthropologists. If it can be proved that the body is at the basis of this inability and that the savage brain lacks in those elements that enable the organism to develop new chemicals in keeping with the changed surroundings and thereby to keep pace with new needs, physical and mental, we shall have proved to some extent that the body is of primary importance in psychical matters. But that knowledge we do not have at present to the extent desired, although the indications are that, inspite of gross similarity, the subtle features of primitive men are unlike those of more advanced races. Whosoever has any knowledge of biology knows that nature can play a hundred themes on the same pattern, and he would be a bold man indeed who would say that because the savage and the civilised look alike, therefore, they are practically identical in their powers and potentialities. Inspite of its unpalatableness in the realm of politics, we are gradually coming to recognise that racial traits are not myths and that the bodily constitution has much to do with our mental equipment, especially regarding our affective and volitional endowment. It is not our business just now to prove how differential equipment arose in the offshoots of the same race, but the fact remains true all the same that all traits are not acquired in course of a single life-history. Social environment remaining the same, very different results are obtained from people of different races, and for an explanation of this discrepancy in the results we are compelled, in the last resort, to invoke the aid of differential organic constitution. So, in order to build up a science of mind, we are at the very outset met by this preliminary difficulty that, after all, our generalisations might be true of one type of constitution and not of another. Psychology finds that it is hampered in its operations by this bodily limitation and comes to recognise very forcibly the old scholastic standpoint that matter is the *principium individuationis*, not only of the person but also of the race. If the East cannot understand the West or the West the East, if the Whites cannot understand the psychology of the coloured races or *vice versa*, something is due to bodily limitations, although much also may be due to interested obtuseness. The knacks of social and conventional life are easily learnt and also matters that are primarily intellectual, but temperamental reactions and habits of will we owe more to racial heredity than to individual learning, and these ultimately fix our type.

It did not escape the most casual of all observers that the temperamental outfit of man and that of woman differed very much from each other. It was also a matter of common knowledge that each period of life had its characteristic outlook upon life. The child, the youth, the adult, the middle-aged and the old have each his own psychology, and so also the man and the woman. It is only in the present century that we are just beginning to know that these distinctions, as well as those of race, are probably due to the same cause. Although this knowledge has not yet been wholly put to practical use and may not be so at any time completely, we are on the threshold of great discoveries regarding the evolution of species in general and of racial and character types in particular. The suggestion of Osborn that very probably the evolution of species was due to the functioning of different types of enzymes or hormones, has been repeated by Keith in respect of racial types, and we are at present nearer than ever before to a satisfactory knowledge not only of racial and individual features of the body but also of the mental compositions of men: This is due to the shifting of the centre of physiological interest from the nervous system to the glandular system in living beings. In a far more subtle way than the nervous system, this glandular system brings about a chemical correlation of the various parts of the organism and determines not only our anatomy and physiology but also our mentality and instinctive reactions. Not only the instinctive actions but also the emotions, as also will, imagination and thought, are now supposed to be profoundly affected by our glandular constitution, and what the changes due to age and sex show is a small part of the whole history. The revelation is disquieting to an academic psychologist who is loth to admit that in mental matters anything bodily should have any great share, and, in proportion as he is unacquainted with the facts of life, he will be disposed to view the increase of biological knowledge as the encroachment of materialism upon a spiritualistic dominion. He may be somehow persuaded to believe in the efficacy of the nervous system in mental matters, for it so happens that, unlike other systems in the body, this system has attained a certain amount of independence of temporary bodily conditions and is not liable to be so much affected by a passing change in the constitution of the blood as the other systems. But the uncomfortable truth is dawning upon him that the nervous system is not so immune to influences as older physiologists thought and that, far below the limits of visibility, unseen forces are at work to give a twist to its functions. Thus, while the train of thought is in motion the chemical constitution of the organism is shunting it on from line to line, and because the train never stops we are under the impression that nothing has altered its course.

That the nervous system is still one of our main aids in explaining mental facts is beyond doubt, but the religious attitude towards it assumed by some physiologists and psychologists is no longer justifiable. The reaction has come from two sources. There is, first, the fact that within certain very wide limits the nervous system is capable of carrying on its functions. There is no doubt restitution of functions, but there is vicarious functioning also, and in certain lower forms the lower brain is capable of taking up some of the functions of the higher. There are, again, undoubted cases of extensive brain-lesions without any appreciable effect upon the mental functioning. Some compensatory function somewhere was making up all the time for the lost portions and giving the individuals all the outward symptoms of normal life. Thus, for mental function, the nervous system need not be of a stereo-typed character—it can discharge its integrating function even in the absence of some essential parts. There is, secondly, the fact that the systems, once ignored in the explanation of mental phenomena, are gradually coming to their own. The sympathetic system, once regarded as an appendage to the nervous system, is now known to discharge important functions in the economy of our bodily and mental life. Not only does it control the vegetative system but through that system it controls the mind indirectly and keeps up that tonicity of the organism without which the nervous system cannot act properly. The nervous system, therefore, acts more or less as the culminating phase of a complicated system of checks and drives, the roots of which are embedded in the other systems so long neglected by the physiologists. The failure to recognise this fact was the cause of some mistakes that still persist in ordinary text-books. Thus, the doctrine of Local Sign, advocated first by Lotze and since then the common property of psychologists, takes the phenomenon of localisation as due to the psychic correlate of stimulation, while the fact is that the organism without a brain is equally capable of localising stimuli by appropriate reflex action, as has been proved by experiments on scratch-reflex on decerebrised dogs. The flow of pancreatic juice, originally ascribed to nervous action by Pavlov and rendered doubtful as due to nervous action by Popielski, has been proved to be due to secretin, a material derived from the intestinal mucous membrane, that is carried to the pancreas by way of the blood stream. Thus, for psychical and purely physiological functions, the importance originally ascribed to the nervous system is being brought within proper dimensions.

I am tarrying so long over this point because in recent psychology and philosophy there is a tendency to regard the intellect as an instrument of adjustment evolved by the organism to meet its situations and not as a God-given faculty to differentiate man from the brute creation. If, then, man's rationality is not absolute but relative to the organism, it behoves us to find out what exactly that organism is. If the Pragmatists are right in holding that the intellect is only a hand-maid of the passional and volitional nature, then all the factors that determine that nature have necessarily to be considered when we want to understand the function of the intellect in any given case. The older theory that memory is the basis of personality, is being replaced by the theory that not intellectual, but affective and volitional, factors are the true bases of personality, and these Wundt and James were disposed to regard as, in the last resort, so many organic sensations. We have outgrown the conception of 'organic,' as in Wundt and James, but we are gradually coming to recognise, more deeply than these writers imagined, the truth of their views that the basis of personality is not the nervous functions alone but, in a truer sense, the glandular functions that are ultimately responsible for our temperament and tendency. Thus, the thyroxin, whose accelerating function has been proved not only in the cases of axolotls and tadpoles but also in the case of defective growth in man, not only regulates the differentiation of tissues and the general growth of the body but also prevents the cretinism of the intellect by preventing infantilism and the wanton one-sidedness of moods which hyperthyroidism and hypothyroidism are bound to produce. Berman puts the matter in this extravagant language: "Without thyroid there can be no complexity of thought, no learning, no education, no habit-formation, no responsive energy for situations, as well as no physical unfolding of faculty and function, and no reproduction of kind, with no sign of adolescence at the expected age, and no exhibition of sex-tendencies thereafter." The parathyroids, again, that regulate the amount of lime in the blood and cells, are also responsible for the steadiness of muscles and nerves. When they are removed the nerves become extremely excitable and the reflexes are oversensitised. The patient is seized with nervousness, restlessness, insomnia and tremor if there is a deficiency of parathyroidal secretion. The Thyroid and the Parathyroid together, therefore, are at the root of our thought and action, and any deficiency in either is bound to warp our normal reaction to reality and give an entirely false outlook upon life. It is not with a mind diseased that we have to deal in such cases but with a body lacking in iodine and lime, and the treatment is not instruction but injection.

Take, again, the other endocrine organs. The pituitary, which consists of two parts, affects the growth of the body, specially the skeletal frame and the supporting tissues, by means of the anterior part, and the function of the accessories of the nervous system, viz. the brain and nerve cells, the plain muscles and the contractile organs in general, by means of the posterior part. Pituitrin, the active substance of the posterior part, not only regulates the amount of salt in the blood but is also responsible for regulating the bodily temperature and the organic rhythm of waking and sleep, diurnal and seasonal, and also for stimulating sexual activity. The overactivity of the pituitary produces not only the frame of a giant but also increased mental power and capacity of sustained work. A cramped pituitary is responsible for a cramped intellect and will, and is the mother of obsessions and compulsions and lack of moral control. There is probably some relation between the thyroid and the pituitary, as Luciani, following Rogowitsch, points out, and probably each can to some extent function vicariously for the other. But if hypophysectomy is followed by great depression and complete apathy, making an animal indifferent alike to caresses and ill-treatment, and also by great motor disturbances, we can probably infer what the normal function of the hypophysis is in the economy of normal life. If to this is added deficiency of thyroid secretion which is followed by the blunting of mental functions, such as the loss of memory, deafness, taciturnity, melancholia, self-absorption, and even occasional unconsciousness, we can well understand what it is to be without the necessary equipment of these secretions and what personality we are likely to develop.

But the glands that have become the object of a more systematic research in recent physiological and psychological literature are the adrenal glands. The cortices of the glands are derived out of the germinal epithelium and are intimately associated with sex characters and also with brain-development. Any interference with their normal functioning alters the whole outlook upon life which is peculiar to a particular sex, producing virilism in women and effiminacy in men. Any disproportion between the cortex and the medulla of an adrenal gland affects the growth of brain-cells and thereby the capacity of thought in the last resort. The interior portion of the gland, called the medulla, has been the subject of classic experiments by Cannon in connection with the emotions of rage and fear and with pain. Its secretion, the adrenin or adrenalin, is caused by deep emotion and, when artificially injected into the blood-stream, produces the organic changes peculiar to pains and emotions. We are just now concerned with the second part of the above statement, viz. the effect of the secretion upon changes directly related to the emotions. If there be any truth in the theory of James and Lange (especially of the latter), we can see what it means to have the manifestations of the bodily states artificially produced by the injection of adrenin into the system. The somatic resonance is accompanied by the corresponding mental states, whether as effects, as James supposed, or as concomitants, as Ribot supposed; and the mental attitude is thus altered by the changed condition of the blood-stream. If, as has been claimed by some, the nature of a dream can also be similarly modified by injecting adrenalin, then it is evident that the unconscious of the Freudian literature will have to be considerably widened in its denotation so as to include not only the subconscious or fore-conscious or co-conscious mental states, but also the purely physiological states of the body induced by the introduction of chemicals. It is immaterial whether the chemical induces certain brain-changes and these, in their turn, stimulate certain centres of thought and thereby bring about the intellectual and affective (e.g. euphoric or melancholic) states in question. The fact remains that, for the production of certain types of thought, we are not absolutely dependent upon chance or upon purely mental factors: the body in all its subtle transformations remains the abiding background of all thinking and feeling.

While we are on the subject, let us not forget that the demands of modern civilised life are so many and so insistent that unless there is an adequate supply of the adrenalin from the glands, there is bound to be neurasthenia or nervous breakdown. It is the adrenal glands that supply the necessary energy for withstanding the storms and stresses of life. A want of adequate supply leads to lassitude and sense of inefficiency in mental and muscular matters. Langley and Elliott have shown that in the sympathetic system the adrenalin acts on the end-organs that unite the nerve fibres with the substance of the muscles; and it is not unlikely that its effects on the voluntary muscles are of a similar nature. Its effect on the blood-pressure is also in favour of the supposition that it has something to do with the mobilisation of energy in the system; it "raises the tone of the vasomotor, respiratory, and cardiac centres, as well as the centres for muscular tone."

Passing over the pineal and the thymus which have to do with retardation of premature masculinity and mental outlook of the adolescent, we may mention the gonads, the sex glands, which have come in for a certain amount of publicity in connection with the rejuvenation experiments of Veronoff. The interstitial glands of the testes and the ovaries have been proved to have important functions, both by castration and by transplantation. They are at the root of our secondary sex characters and control the whole apparatus that determines our peculiar reaction to environment according to sex. Darwin first drew attention to the remarkable susceptibility of the sex instinct to a change in the environment by pointing out the difficulty of inducing certain types of animals to breed in captivity. He was also the first to draw attention to the role of sexual selection in the origin and preservation of species. Weismann tried to establish the early segregation of the germ-cells in order to establish his theory of germinal variation. But it is only in recent times that we are in a position to assert with confidence why castration and shrinking of the interstitial cells in old age have a similar effect on the body and mind—why, for instance, social service which requires a certain amount of detachment from the cares of family life is mainly an affair of middle-aged women and not of young girls. It is not because the girls are lacking in kindness and altruistic impulses but because the energy for that kind of work in not available owing to the activity of other glands of reproduction. Widows, old maids, sterile women and women approaching the climacterium are the best social workers, not only because they have more time but also because they command the necessary energy for the purpose. The effect of the sex glands upon mental outlook is not a new discovery. Hysteria connected with approaching womanhood (especially when the sex instinct is imperfectly satisfied), insanities of pregnancy and puerperium, the suspicion, jealousy and insanity at the time of the menopause have been made familiar to us by writers on abnormal mentality, e.g. by Mercier. That at every crisis of the sexual life we undergo a certain amount of transformation in our bodily and mental equipment is such a familiar event that it is likely to be overlooked. If Freud has drawn attention to that fact alone, he deserves our best thanks, whether his theory of the polymorphous perversity of childhood and the sexual etiology of dreams and other mental states (e.g. religion) may or may not be acceptable to us in their entirety.

Where then do we stand? We have found that at the basis of our individual personalities there are certain glandular factors once overlooked, and that our racial, familial, sexual and temperamental constitution owes a deep debt to the bodily factors. If then we find that psychologically we are not the same, we must apportion the causes thereof impartially to the body and the mind alike, and must not run away with the notion that when the education and opportunities of the individual are duly noted we have the whole cue to the personality. What constitution can do we know from the mentality of identical twins, and what training does we know from experiments on familial constellation (though there also constitution has a great influence). No less than the biologist, the psychologist is faced with the questions of heredity and variation, and he has, in addition, to take note not only of the physical but also of the social environment, and also to discuss the transmission of mental traits, which is harder to detect than the transmission of bodily characters. It is not easy to say how far mental traits mendelise. The formula of progressive diminution is all right for class work, but when it comes to actual practice we find that all are not able to say like Goethe from what parent they got what character.

Thorndike has tried to enumerate some of the factors that determine the character of an individual intellectually. The causes of individual differences enumerated by him are sex, remote ancestry, near ancestry, maturity and environment. Now, maturity includes the functioning of the various bodily organs, including the glands; so that we find that the organic factor is predominant in his enumeration also. What the original equipment does, even in such a simple matter as colour preference in babyhood, has been shown by Preyer and Baldwin. If one had the patience, one would have found that no two babies had the same biography, and that, inspite of close similarity in environmental influences, children grow up differently. It is only broadly then that we have a psychology of childhood just as it is only broadly that we have a psychology of adult life. Constant subjection to the same environmental influences may have an obscuring effect upon the differences of personality, the more so when the individuals are not children but grown-up men who are expected to conform to a (social) regulation pattern by curbing some of their original tendencies and atrophying them by disuse. The proportion of original to acquired tendencies is much greater in childhood than in adolescence and maturity, and the similarities of childhood are the similarities of organic needs, impulses and reactions. We draw out differential mental abilities in children by putting them in different situations, physical and mental, and thus nurture supplies those differential stimuli which, acting on an original constitution, feed or starve innate capacities and lay the foundations of the future personality. In the development of that personality social conventions and social ideals have a great part to play, for it is only as a freak that the growing individual can hope to develop in a way unforeseen and undesired by the society at large and play the role of a reformer of social ideals and social morals. It is the type that has the greatest chance to survive, and in society, no less than in the world of life, mutation is a rare phenomenon. It is. then, inspite of our societies, that we become geniuses and heroes—society has a levelling tendency and a smothering effect upon differential development. The Superman is not wanted in society and that is why he is so late in coming. Society has a dread of the uncommon, for it does not know how to deal with it. It wants manageable members and uniform behaviour pattern. The science of psychology would have been far more difficult to formulate had society agreed to let individuals have their own *proper environment* as stimulus. What the potentialities of growth are we are now coming to realise in a small way in the new schools based on differential psychology. Just imagine what the results would have been, had Society had a Dalton Plan or even a Project Method for its growing members. Of course, we know also what it means to allow every member opportunity to develop according to his own genius. The limitations are not only of means but also of ability. It is not always that you can hope to get a teacher for every single individual, and many a Hellen Keller is leading the life of an idiot simply because the sympathetic and able teacher is not forthcoming.

Before we leave the subject of individual instruction, let us pay the due meed of praise to those who have discovered the way to approach every individual mind so that its potentialities should not run to waste. The mentally deficient is now a lesser drag on the communities in many lands, because it has been discovered that the body can learn and remember where the intellect fails. Ribot had indeed drawn attention to that fact and in recent literature the names of Hering and Semon are familiar to all psychologists in that connection, but to put this knowledge to practical use has been the work of teachers and social workers. We have now schools to teach the mentally deficient many useful arts that gain a livelihood, and it may be, if there be any truth in Baldwin's theory that righthandedness quickens the brain, that the more the mentally deficient person works, the more dexterous does he become by the dawning of a new intelligence. The spread of vocational education may prove the salvation not only of the average man but also, where manual training preponderates, the emancipation of many a slumbering brain. We have nothing to do here with raising the dignity of labour in the eyes of the people; we are concerned here only with the psychological effect of manual training on a section of society on whom intellectual education is sheer waste of time and energy. The rise of Industrial Psychology is really a continuation of the work of rousing social conscience to the need of non-academic education and of directing men's attention to the actual facts of social life: incidentally, it is a revelation of the differential equipment of minds and the possibility of utilising it for social purposes. We are on the threshold of discovering a new caste-system based not upon heredity but upon natural equipment. If we can, at any time, find out the character types in terms of various mental functions, in terms of imagery, emotion and reaction, and can further show how far such types breed true, we shall be solving one of the obscurest problems of psychology and biology alike. But at present it would be presumptuous to say that we have discovered the types in their infinite subdivisions; all that we can affirm is that probably Jung's psychological types are as near as what we want for social dealings. After all, it is with a certain end in view that we classify men and, seeing that the persons found in society are not yet known to be unique syntheses of certain qualities, we are satisfied as soon as we know enough about them to distinguish them from the rest of their class. It does not pay to study a single individual intensively, and it may be remembered to our profit that such study we owe to those who, like Preyer and Baldwin, were prompted by paternal affection, or those who, like Freud and other psychoanalysts, originally got the wages of their labour. It is only latterly that the study of children and social misfits has assumed a certain amount of disinterestedness and, I may add, become the pleasant occupation of incompetent dilettanti at the same time. But the risk notwithstanding, it is desirable that we should know exactly what the science of psychology professes to discuss, for we are likely to run away with the notion that it deals with the stereotyped because it is a science. Not at all; it is with the average that it deals, and not even with the average of a homogeneous group.

If to-day we are so grateful to Binet and Simon for their pioneer work in the measurement of intelligence, it is because they drew pointed attention to the differences among children inspite of similarity in chronological age. Their technique has been modified and improved and we are now in possession of better appliances for the measurement of differences, but their researches opened up a vista that is not yet closed. It is yet a moot point as to what exactly the measurement of intelligence means, for the term 'intelligence' covers a wide variety of mental functions; but it has been possible to show that wide individual differences occur and that, although for convenience we form manageable groups, that does not take away from the fact that we are differentially equipped for the battles of life. If we start with the assumption that not what we are but what we are expected to be matters in education, we shall be ignoring the warning of Rousseau, Pestalozzi and Froebel that a child is not a miniature adult and that education is not so much an instruction as an opportunity. We must develop according to our own genius if we are to attain the full stature of our personality, not only as a race but also as individuals. The new educational movements are primarily meant to give every child an opportunity to develop through work and play as a living growth and not as an industrial manufacture where the patent stamp of the architect is too palpable and too oppressive. Froebel, Montessori, Burk, Parkhurst and others have launched systems of individual instruction in keeping with individual psychology, and although in many less known experiments the sole motive is to do something new, some have proved their stability by increased output of work and the more congenial occupation of school-children. If anyone is interested in the subject of individual instruction, he will find in the second volume of the Twenty-fourth Yearbook of the National Society for the Study of Education sufficient materials to inform and impress him. He will also see the difficulties in the way of teachers, for it may be taken as an axiomatic truth that easy education for children means labour and intelligence for teachers. The ferrule and the rod a teacher can use effectively as a weapon of punishment but seldom as an instrument of instruction; the new methods of instruction demand people who would teach lessons not with their hand but with their brain. You will have to pay such teachers, and pay them quite decently, so that all their energy may be reserved for evolving improvements in their technique. Society will have to be reminded of the old saying that unless you pay your teachers better than you pay your jockeys, your horses would be better trained than your children; and nowhere, except in the country of the Houyhnhnms, is that a desirable consummation. People must rise to the consciousness that education is a social duty and that we pay for our neighbours' children's education because we want our own children to have better social surroundings. There is too much of dull uniformity in our educational systems, and unless we are prepared to shoulder the financial burden of individual instruction in the community and help each child to find an individual outlet for his innate and acquired capacities, let us not complain if we have so few geniuses in the country.

We have observed before that society has a levelling effect and that the social mill has a tendency to turn out uniform products. But we do not thereby deny that differential outfit has its own effect on the resulting growth. It is upon a given constitution that society has to act and that constitution is determined ultimately by ancestral and ontogenetic factors. We have more accurate knowledge of the broad reactions of the body and mind, such as reflex, instinctive and emotional adjustments, but the finer shades of difference are all peculiar to the individuals and, in respect of them, the science of Psychology has to remain satisfied with generalisations that are approximate and knowledge that is uncertain. Even the original constitution, after years of reaction and adjustment, comes to get into a habit, and thus a peculiarity springs up in course of time and establishes a character for the individual. Not only individual life-history, but the racial history too, as Jung points out. This racial history, while it fixes the similarity of the members of a race, serves at the same time to distinguish them from members of other races. This racial Unconscious, whether as organic outfit or as instinctive equipment or as mental impression, gives the characteristic outlook upon life and provides the basis of national and racial psychology. But, far deeper than these racial factors, there are other factors that are generic and hark back to the times when man was learning the craft of intelligence in competition with animals and laying the foundations of that rational behaviour which subsequently raised him above the beasts and made him the crown and glory of the living creation. Deeper than these even, there are factors that ally him to the beasts, which, even after centuries of civilisation, surprise him at unexpected moments by surging up out of the vast deep of his mental constitution and remind him that the beast in him has not been completely laid and that the tiger and the lamb lie together in the ambushes of his mind and make a curious fraternity. But are there deeper elements than these even? Is man carrying in him also the vestiges of the plant and the stone out of which the evolutionists would fain make him rise? The torpor of plants, in which Bergson believes, is evident in the constitution of idiots and the temporary stupidity of even the most refined intellects on certain occasions; while the instinct of death, which Metschnikoff believes to be a normal reaction of old age, Freud believes to be due to the desire of the individual to sink back into the dust out of which life originally arose.

What a complex constitution man is carrying within his slender frame! There is an affinity with the whole of creation in respect of this or that aspect of his nature, and he is a bold man indeed who would say that he has been able to fathom the depths of personality in any individual case. Man is inscrutable both in his constitution and in his growth. This is why complacent predictions about him turn out to be so frequently false. When we study him as a member of the human species we run away with the notion that we can deal with him as the sample of a class, just as we do in Chemistry and Physics. He is the representative of his class in a general sense in respect of his organic outfit, i.e. in respect of just those things which only touch the fringe of the science of Psychology. He is in a looser sense the representative of a class in respect of certain generic unconscious and racial factors, which come into view in certain fundamental reactions connected with hunger and sex —in certain instinctive reactions, and, following upon them, as McDougall points out, in certain emotional adjustments of a fundamental character. But he is not the representative of a class when we take his entire biography into account—the whole of happenings in that particular spatio-temporal tube, as Russell would say. That invisible factor which lays down the basis of difference, viz. Memory, acts as a dividing gulf between him and his neighbour in certain peculiar ways. James, Bergson and Russell have all treated this point with consummate ability, and although the ultimate form in which this memory is supposed to act is not identical with the Unconscious of Freud, we may for practical purposes admit that the latent impressions of past experience bring about an intellectual interpretation and an emotional outlook which are peculiar to each individual and give each personality a characteristic stamp. We have in recent years witnessed the publication of many researches on individual mental functions; but the most important, because the most concrete, investigations have been on the reactions of men as social beings. Man is being studied not only in his individual capacity but also as a member of a society and is being judged in respect of intelligence and normality with reference to a particular social setting. There is scarcely any faculty of his that is not being tested of late to find out how far he conforms to the social standard. His imagination, his reason, his emotional outfit and even his sense of the ludicrous are being systematically investigated, and practical use is being made in some countries of this knowledge regarding him. He is being studied as the member of a crowd, as a combatant, as a peaceful citizen and as an abnormal individual. The rise of Social Psychology and Individual Psychology is a welcome sign that man is becoming an object of increasing interest to his fellow-men, not as an abstract being but as a creature of flesh and blood. He is becoming personal as an object and not an impersonal item of psychological treatment. Both as a child and as an adult, he is being watched and his course of development followed with interest and anxiety.

One word more and I will finish. The rise of the individualistic way of studying man has been in recent years due to one man more than to anybody else, I mean Sigmund Freud. Jung and Adler have improved the method in some matters, but we owe to Freud the beginning of this new study and its recognition in academic circles. His investigations have made us aware of the pitfalls of the personality in childhood and youth, and have explained, more satisfactorily than before, many of the obscure traits of individual lives. He has drawn pointed attention to what environment can do and what a large part the instincts incidental to each age play in the development of normal personality. Neuroses, psycho-neuroses and psychoses are now within prospect of being explained and treated as diseases of abnormal adjustment; and although opprobrium and hate have fallen to his share the social conscience has been roused to many crying evils and a changed attitude towards the misfits of society is slowly coming on. Minds are no doubt being regarded as single cases requiring individual treatment, but they are being brought under control according to ascertainable laws; and thus the science of psychology which originally fought shy of the Unconscious as an impalpable realm of the mind is now recognising it as the dynamic background of conscious personality and as a welcome explanation of overt mental reactions. We now realise what strange ways the mind has of conserving its experiences and utilising them in subsequent conduct. The alienist and the educationist are gradually making an alliance and the social reformer is not oblivious of the results of their combined labour when dealing with his own special problems, just as he is not oblivious of the biological investigations regarding the transmission of acquired characters. If normal life depends on normal reaction and normal reaction on normal environment and adequate opportunity, it becomes at once a social duty to provide the environment that will call forth the appropriate reaction of the age of the subject. Where home-life does not supply the necessary environment for proper growth, the school steps in, especially in the case of those whose home is modelled on the needs of the adult members only. The large use of women in lower classes of boys' schools, not only in the West but in the East as well, is meant to impart that home touch to the instruction of children which the mother alone is expected to impart. At that age the normal environment is the affectionate care of the mother, and it is this that the woman teacher is expected to supply. In some systems the nursery is simulated, and in large industrial centres, where the mother has to labour for the bread of the family, such a nursery is an indispensable adjunct to every factory and every workshop. The eternal question of finance stands in the way in every such social venture, but finance has to be found somehow for, after all, it is man that is the ultimate end of all social endeavour and money is meant to fill society with the largest number of desirable citizens. Till social obligation is raised to the status of paramountcy, the problem of education will never be solved. With education conducted on right lines and providing opportunities for all, there is the prospect of a new orientation in social gradation and social development. Without it, the wheel of social progress will be constantly clogged and the friction will produce heat in the social system. We must once and for all abandon the idea that mind is an abstract principle loosely related to the body and to society, and that, as such, it may be grown to any dimensions. The reading of psychology does not justify that attitude. It is only abstractly that we are all equal and the child is the adult in miniature. The truth is that we differ and that education is the opportunity given to bridge as much as possible the gap of difference. Not however in the uniform pattern of machine-turned articles, but as organic factors of a vital system in which the parts are sufficiently alike to belong to the same system and yet sufficiently different to fulfil different needs. In this noble endeavour one fact is to be guarded against, and that is the confirmation of the class prejudice that believes in the transmission of acquired abilities through untold generations. Communal and class pride has based itself on the assumption that opportunity is of very little avail in the regeneration of the down-trodden. Let us accept unpleasant facts upto their legitimate limits and prevent the neurotic, the insane, and the idiot from multiplying. But let us not create limits where there are none, and throw obstacles in the way of social regeneration of the down-trodden by denying to nurture its legitimate share in the uplifting of the mass.

We started with the question whether Psychology is a science in any sense. Define human life in terms of reaction to environment and you will have a science in some sense. But if you start with an adult constitution, you will very soon despair of getting into the scientific field. The difference between man and man is more than the difference among the isotopes of chemical elements, and the scope of uniformity is very limited so far as the conscious reactions are concerned. But, below the level of the conscious and the individual, there are factors that knit man to man as against the brute creation, and as one community or race against another. It is the purpose of the psychologist to expose the basis of difference, and even though each man may be proved to be a law unto himself, the purpose of psychology will be served if it can show that it is within the competence of society to control social development within limits and to bring about a rapprochement among its members. Let us accept the differences that we find, but let us all work towards the smoothing of racial, social and communal edges. We shall never probably succeed in eliminating all differences nor is that the object of psychology as an applied science. But let us all live for the day when the differences will be minimised to their lowest point, and when men fail to agree they will understand the obstacles at work and pay mutual respect to each other's feelings. The best is not to differ and the next best is to know why we differ. Let there be equal opportunities for all according to the social and individual constitution and let it not be said that partiality warped the sense of social obligation in any individual or any community; and, in order to take the first step towards that rightful consummation, let us all turn, first of all, to those whom we have hitherto neglected.

Abstracts of Papers.

1. A sphygmographic study of Brain Fatigue.—*By* D. N. SEN.

I. Sphygmograms taken during mental work are indices of circulatory changes induced by the exercise. There is a gradual lowering of blood pressure and a weakening of the heart impulse, but arterial tension is maintained. Frequency of pulse is not materially altered though the beats grow undoubtedly feebler.

II. Experiments on adults (18 to 20 years of age) prove that (1) open air is the best environment for brain work; (2) the average time of fatigue is about 45 minutes; (3) time of recovery, 12 minutes; (4) class routines should be so arranged that no period is more than 45 minutes, and 10 minutes' time be allowed for recovery; (5) class rooms should be vacated after every period; (6) the best time for mental work is about 8 a.m. in the morning and after one hour's rest after the midday meal.

2. The influence of environment on the education of children.—*By* J. M. SEN.

In all problems of education two things are of fundamental importance; one is the child who is to be educated and the other the environment in which he grows up. But both are variables; no one can fully predict what a child is going to be, nor is it impossible to change his environment to a certain extent. *Education is therefore a function of two variables.* The paper gives the results of investigations conducted in slums in Calcutta. The intelligence quotients of a number of boys while in the slums were first calculated. A few of them were then removed to a better environment (*viz.* that of a good school) and their general intelligence was again determined by the Otis tests specially modified for the children in Bengal by the author of the paper and his colleague, Professor. G. Dasgupta. The new intelligence quotients showed that the change of environment helped considerably in improving their general intelligence.

3. An evaluation of the results of teaching efforts in Bengal. —*By* M. R. MITRA.

I. The popular estimate—its worth. Criteria of a scientific evaluation if any such is possible.

II. Factors in education—how far convergent or divergent in Bengal.

III. The curriculum—a critical study of its determinants.

The Renaissance—the political or official outlook.

IV. Opportunities for self-expression—how well utilised. The contribution of educational effort.

V. The present day demand—its genesis and value: how to meet it in education.

4. Biological conception of Libido.—*By* K. C. MUKHERJI.

1. A general review of the definitions given by Freud, Sidis, Adler, Bergson, McDougall, etc.
2. A critical analysis of the manifestations of energy as conceived in physico-chemical terms.
3. Physical energy as differing from neural and mental energy.
4. Similarities between the neural energy and the mental energy as viewed from the biological standpoint.

5. Libido conceived as neuro-psychic energy.
6. The relation of the tantric serpent-power (kula-kuṇḍalinī śakti) to libido.

5. Measurement of difference.—*By* K. B. MADHAVA.

In this paper a comprehensive statistical analysis is undertaken of the scores in certain university examinations with a view to study communal differences on a specialized scientific basis. In addition to the central tendencies and the measures of scatter, of variability and of concentration, correlations, goodness of fit in random samples, contingency of association after the elimination of the chance component and the threshold limens are computed.

6. Experiments conducted at the Teachers' Training College, Dacca.—*By* G. B. BHATTACHARYYA.

I. The Dalton Laboratory Plan as now carried out in the Armenitola Government High School is based upon the results of observations carried out in 1924. The Dalton Plan has been introduced in the top four classes of the school, while the traditional method continues in the lower four. Thus the school follows a mixed time-table and the Dalton seems popular. The noteworthy points of the experiment among others are enumerated below.

(*a*) There are *three* time-tables for the Dalton classes during the daily session—two for free study and one for formal lessons. Each period of Free study is for a group of subjects but no allocation of time is made for each.

(*b*) The number of "laboratories" as of "specialists" is limited. Each specialist takes also an extra subject including the optional subjects for the Matriculation and Sanskrit.

(*c*) The *printed* assignments are for a month. "Checks" are simple and Monthly Tests are the rule.

(*d*) There are arrangements for group work; hence the spirit of co-operation is encouraged.

(*e*) Special measures have been discovered to prevent *copying* and *undue strain on teachers*, to ensure the marking of *ad interim* written work, vocal practice and oral lessons with pupils at different stages. Treatment of four different types of boys is considered.

II. The Single-class Dalton Plan seems to make little children happy and ensure greater success than the traditional class method.

III. Projects do not seem to fit in with our school conditions. Three Projects not very long were tried—one individually and two in groups during the free periods of pupils. This work was absolutely voluntary and additional.

IV. Enough trouble has been taken over individualising instruction in Reading, Arithmetic and Hygiene in primary grades. The experiment suggested special assignments which were constructed and printed at Government cost. If the assignments are not constantly modified in the light of experience best results cannot be achieved. Two other problems that need solution are (*i*) individualising instruction in One-teacher Primary schools with two and more often four classes, and (*ii*) devising means for keeping those tiny children, who have not yet begun the alphabet, occupied with tasks not purely mechanical.

7. Cessation stimuli in reaction experiments.—*By* K. C. MUKHERJI.

It is found that the reaction times to the presentation of the visual stimulus and to its cessation show no appreciable difference, while in the case of tactual stimulation the difference between the two types is appreciably great. The introspections of the subjects and their individual records for *the cessation reactions to touch stimuli seem to indicate that* rapid adaptation of the pressure sense to contact stimuli is the source of confusion regarding the persistence of the latter. This leads to abnormal reactions, both positive and negative, to cessation stimuli as compared with the normal reactions to presentation stimuli of touch. The indifference shown by the visual type towards the mode of stimulation is probably due to the fact that the balance of neural energy in the occipital lobe is very easily upset.

8. Self-Government in High Schools.—*By* G. B. BHATTACHARYYA.

The Emancipationists advocate unrestricted freedom for school children to develop along their own lines. They are in favour of self-governing organisations in the form of courts and councils. The New School movement advocates the idea of freedom combined with responsibility under direct control of adults. Badley's School Parliament is calculated to combine freedom and responsibility and to reconcile the claims of individuality with social obligations. This makes school a community and not a herd. Badley's School Parliament is a form of "dyarchy" worked in Bedales to enable School pupils to secure intellectual freedom and to have a training in self-control and social responsibility.

Dr. O'Brien emphasises merely the intellectual freedom to be secured in a healthy atmosphere with the wise co-operation and control of teachers. Self-governing organisations according to her are empty forms and often degenerate into mere shows.

The Extra-extremists recommend that complete control of school and class should be handed over to pupils. Professor Adams condemns this as being nothing better than Bolshevism. The practical teacher never believes that such organisation will ever ensure self-control and social responsibility. Nor is this consistent with actual life.

The principle of Self-Government applies to all countries but the forms must differ. Every nation has its own habits of life, its own traditions and ideals that go far to shape the mental attitude of its members. Self-government through school Parliament or Courts and Councils is unworkable in this country as being against the force of tradition and the age of scholars varying from 6 to 16, at any rate from 8 to 16. The dramatisation of City or State governments suits America admirably well, but this in India is sure to hold before children a false ideal never to be realised.

The solution of the problem of Self-government in schools in India lies in intellectual freedom to be ensured by the organisation of class work. For this purpose two plans seem worth trying—O'Brien's scheme of Vertical Classification and certain methods in class work, and Parkhurst's Dalton Laboratory Plan. O'Brien's plan, otherwise called the Howard Plan, is complicated and seems more suitable for Girls' than for Boys' schools. The Dalton Plan may be worked without its complications and embellishments to suit local conditions of schools. The Dalton plan is extensively used in England (in 1500 schools), is in use in America, Australia, New Zealand, South Africa, France, Japan, Russia, Poland and Africa. This new movement which has spread over all the world seems to show the right lines along which an attempt is worth making to secure self-government in schools in and through intellectual freedom characterised by Trust and Responsibility.

9. The Chance factor in Intelligence tests.—*By* M. V. GOPALASWAMI.

The paper is an examination of the element of chance entering into the choice of the right answer from amongst four alternative answers.

10. The Laughter instinct.—*By* M. V. GOPALASWAMI.

A suggested modification of MacDougall's theory of laughter.

11. A preliminary report on some experiments with white rats on the inheritance of acquired habits.—*By* M. V. GOPALASWAMI.

An attempt at corroboration of recent researches of Kammerer and Pavlov on the inheritance of acquired habits.

12. Effect of mental work as measured by dynamometer.—*By* MANMATHA NATH BANERJEE.

The paper reports the data of a series of experiments on college students before and after the college work.

13. A Sand-motor:—*By* G. S. BOSE.

The paper reports on a new pattern of Sand-motor that is in use in Calcutta (and also Dacca) Laboratory. The motor can be employed in a number of psychological experiments and has the advantage of cheapness, and ease of manipulation.

14. Mental work in isolation and in group.—*By* N. N. SEN-GUPTA, *and* C. P. N. SINHA.

The paper presents the results of a series of experiments in regard to the output of an individual's psychophysical work when alone and when placed in a group of persons engaged in the same task. A simple type of psychophysical test namely, cancellation, was used. The following table gives a sample of the result:—

Gain in percentage over previous day's work

	In isolation.									In group.		
Subject No.					days.							
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
I.	..	15%	17%	−55%	11·1%	0%	2%	0%	−4%	23%	1%	0%
II.	..	11%	55%	0%	3%	3%	−2·5%	2·2%	1·7%	14%	6%	2%

It is a noticeable fact that the output in the group diminishes after a time. The hypothesis put forward is that the distraction caused by the group environment leads to a greater concentration of attention and hence to the increase of work. As soon as the distraction effect disappears, the output shows a decline.

15. Effects of practice in a simple psycho-physical work.—*By* GOPESWAR PAL.

The experiments reported in this paper were devised in order to bring out the individual differences in the process of attaining a level of practised efficiency. The task was the execution of relatively simple and definitely controlled movements. The result is considered under four heads: (1) the individual type of work, (2) the total output of work, (3) the initial output of work, (4) the comparison of the initial output of a day with the preceding days final output. There was a marked difference between individuals with respect to the nature of the practice course. The maximum output of work was found not during the last days of the experiment but during the 3rd quarter of the period; and it was accompanied by a greater constancy of output. During the first period of work, the initial output of a day was usually higher than that of the previous day. But during the latter part of the investigation, the days began with a lower initial output. The initial output of a day was usually lower than the final output of the preceding day. But in the case of one individual, there was a marked gain. For this, the hypothesis of 'unconscious perfecting of associations during rest,' put forward by Angell and Loorer, is suggested.

16. An experimental study of definitely and indefinitely directed attention:—*By* N. N. SENGUPTA *and* SUDHIR KUMAR BOSE.

When the object or the fact is specially given and the subject is asked to attend to it the attention is definitely directed. When the fact is described only in general terms, the attention to it is indefinitely directed. Under the conditions of the experiments it was found, the ratio of the output of work as between the first and second series of experiments is 3 : 1 to 2 : 1. The correlation worked out by the 'method of ranks' is ·8. The smaller score in the second case is explained by the difference in the operation of the memory factor under the two conditions. The correlation is due to the common attentional factor.

17. A report on the time adjustment of the Hipp's Chronoscope.—*By* M. N. GANGULY.

The paper points out certain difficulties that inevitably arise in adjusting the Hipp's Chronoscope to the Wundt control hammer.

18. Studies in involuntary movements:—*By* N. N. SENGUPTA *and* M. N. SAMANTA.

The fine tremors of a finger at rest have been recorded by a specially made aluminium writing lever. The record shows a wavy line with indentations. The 'waves' are due to respiration; the indentations are due to tremors. The number of Tremors under normal condition is fairly constant for an individual. Musical notes and mental work seem to introduce a greater regularity in the tremors. The following table gives a sample of the results.

	Normal Condition.		Organ sound.		Mental Work.	
Subj. No.	Aver. trem. in 5 sec.	M.V.	Aver. trem. in 5 sec.	M.V.	Aver. trem. in 5 sec.	M.V.
2	23·30	1·92	24·60	1·56	26·10	·32.
3	25·00	1·06	31·50	·90	30·80	·38.

The greater regularity of the tremors when mental work and musical notes are employed is explained by the hypothesis that these produce a greater regularity of respiration. For they induce an attentional state. Regularity of respiration accounts for the regularity of tremors.

19. The differential threshold of active touch.—*By* M. N. SAMANTA.

"Attempts to test the sensible discrimination of the 'muscle sense' by active pressure against a resistance of variable intensity" says Külpe, "are ambiguous in their significance" The purpose of the series of experiments reported in the paper is to test this view. The resistance of variable intensity in this case is a rubber bulb.

The result seems to be determined by three sets of factors :—

(1) time taken in exerting pressure;
(2) tactual impression;
(3) kinaesthetic sensation.

The direction of attention to one or the other of them exercises a determining influence upon the result.

20. Individual differences in the memorisation of nonsense-syllables.—*By* HARIPADA MAITI.

Twelve non-sense syllables were visually presented to 24 students of Psychology, the students working in groups of 5 and 7. The "complete memorisation method" of Ebbinghaus was used. A modified form of Meuman's system of scoring was adopted. To sum up the results :—

(1) The students who formed a homogenous group educationally can be resolved into three sub-groups of good, moderate and bad memorisers, if memorisation efficiency is judged in terms of number of presentations required for full reproduction.

(2) Co. of correlation between the amount of first correct reproduction and the number of presentations needed for full reproduction=·63 P.E.=·117.

(3) Cos. of correlation between number of presentations for full reproduction and, (*a*) teacher's estimate of intelligence, and (*b*) I.Q.S. determined by Stanford-Binet tests are ·69 P.E.=·078 and ·53. P.E.=·123 respectively. Correlation between amount of first reproduction and estimated intelligence=.72 P.E ≐·084.

(4) Some distinctive peculiarities of good and bad memorisers. Memory for order seems to be specially lagging in bad memorisers. Some sort of implicit plan of procedure and co-ordination of syllables into increasingly complex groups are generally found in good memorisers. Also some interesting differences between the two classes of memorisers in respect of numbers and kinds of errors committed during the reproductions are indicated.

21. A report on the application of the stanford adult tests to a group of college students.—*By* HARIPADA MAITI.

Five tests of the age-group XIV, seven tests of the "Average Adult" group and three tests of the "Superior Adult" group were applied on thirty-two students of Psychology and two outsiders. The language tests and the instructions were given in the vernacular. The average *chronological* age of the group was 21 years and 7 months. To sum up the results :—

(1) There is a mental retardation of more than 6 months on the average, and the average I.Q. is 95. The low average can be traced to the presence of a large percentage of Dullards (37½%) in the group. The frequency histogram of I.Q.S. shows three modes—one at 116, another at 101 and the third at 84.

(2) Co. of correlation between I.Q. and teacher's estimate of intelligence= 50. P.E =·103. Error of the scale applied to the group does not seem to be large.

(3) The group has done worse in the *constructional* tests than in the *language* and *immediate memory* tests. Psychological characteristics of three sub-groups of superior, medium and dull students are discussed in the light of the distribution of scores in the special kinds of tests. The superior group

generally excels the other groups in tests involving higher mental processes.

Two neurotic cases yield rather high I.Q.S.—100 and 105.

22. The duration of children's attention:—*By* N. N. SENGUPTA.

The paper is based upon a series of experiments for determining the duration of children's attention under four different kinds of task, namely handling dough, drawing lines, arranging blocks and counting verbally. Three 4 year old, 1 five year old and 2 seven year old children were taken as subjects. It is found that with the 4 year olds handling dough has the longest duration; with the seven year olds the arrangement of blocks has the longest relative duration. The hypothesis put forward is that ideas in the latter case and kinaesthetic sensations in the former case operate as determinants of duration. A variety of ideas and a variety of movements in both of these instances can be maintained in reference to the same object. Attention, thus, be maintained for a longer period in relation to the same physical object.

23. A study of imagery in the works of Rabindra Nath Tagore.—*By* SARASILAL SARKAR.

The paper studies the striking recurrence of three kinds of imagery in a constant order in the works of Rabindra Nath Tagore.

24. Vocational psychology with special reference to the postal service.—*By* OWEN BERKELEY HILL.

The extravagant awe and attention which the Mails call forth in the minds of the public as well as of the postal employees cannot be properly explained without invoking the aid of unconscious factors. The devotion to duty and occasional heroism of postal employees must be ascribed to the fact that the Mails and everything connected with them represent certain birth symbols. A subsidiary unconscious motive at work is the veneration for the written word of which we know other instances in secular and religious matters.

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H

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Bhadbhade, K. H.
Bhagwagor, K. G.
Bhandari, R. M.
Bharda Sorab, B.
Bhate, Vasant Govind.
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RULES.

INDIAN SCIENCE CONGRESS.

I. The administrative work of the Congress shall be carried on by an Executive Committee, who shall submit such questions as they think desirable to a General Committee at its annual meeting or at a special meeting of which satisfactory notice shall be given.

II. The General Committee shall consist of all full members (*Vide Rule XI* ;) who have attended three meetings (including that actually taking place at any time) and those members who have held office in the Congress. This Committee shall meet at least once at each Congress, usually in the middle of the meeting.

III. The Executive Committee shall consist of the President, the retiring President, the two General Secretaries, the Treasurer of the Asiatic Society of Bengal, the General Secretary of the Asiatic Society of Bengal and three members elected by the General Committee at its Annual General meeting. The Executive Committee shall have full powers to transact all business in case of need, notwithstanding any limitations herein laid down.

IV. The Council shall consist of the members of Executive Committee, of the Past Presidents resident in India and five other members appointed by the General Committee at its annual meeting.

The Council shall be consulted on matters of general scientific importance and policy.

V. The nomination of the President shall be made by the Executive Committee and submitted for confirmation to the General Committee.

VI. The Sectional Presidents shall be appointed by the Executive Committee.

(*Experience shows that there is not time for any other arrangement to work satisfactorily.*)

VII. The two General Secretaries shall be nominated by the Executive Committee and submitted to the General Committee for confirmation.

VIII. As long as the present relationship with the Asiatic Society of Bengal continues, the General Secrotary and the Treasurer of that Society shall be members of the Executive Committee.

IX. The Local Secretary (or Secretaries) and the Local Committee for any meeting of the Congress shall be appointed by the Executive Committee.

X The Local Secretary (or Secretaries) and the local Committee shall assist in making arrangements for the reception and entertainment of the visitors and for the distribution of letters at the meeting.

XI. There shall be three classes of members :—

(i) *Full members :* Annual subscription *Rupees ten.*
(ii) *Associate members :* Annual subscription *Rupees five.*
(iii) *Student members :* Annual subscription *Rupees two.*

(Student members must be definitely certified by the principal of their College as *bona fide* students.)

Only full members have the right of communicating Papers to the Congress and they receive free of charge all publications. Associate and Student members have the right of reading papers before the Congress provided they have been communicated by a Full Member.

[1] XII. The following procedure is to be adopted for making any additions or alterations in the above rules :—

(*a*) Proposals for additions to and alterations in the existing rules are to be sent to the General Secretary at least two months before the meeting of the General Committee at which they are to be moved. The General Secretary, on receipt of such proposals, shall circulate them to all members of the General Committee who paid their annual subscription at the last session of the Congress.

(*b*) Any amendments to the proposals shall be sent to the General Secretary at least a fortnight before the meeting of the General Committee.

[1] XIII. The proposals with amendments shall be brought up before the meeting of the General Committee (with remarks of the Executive Committee, if any) and declared carried, if accepted by a two-thirds majority of those present at the meeting.

SECTIONAL COMMITTEES.

XIV. (*a*) The Sectional Committees shall consist of not more than three members who shall be

(1) The President of the Section (convenor).
(2) The retiring President of the Section.
(3) One member elected by the General Committee at its Annual General Meeting.

(*b*) The Sectional Committee shall arrange and referee all papers to be read before the Section.

(*c*) The Sectional Committee shall have power to fill vacancies during the year of their appointment.

(*d*) The Sectional Committee shall nominate annually a President for the section for the consideration of the Executive Committee.

PAPERS.

[2] XV. (*a*) An abstract of any paper to be read at the Indian Science Congress must be submitted to the General Secretary or the President of the Section concerned not later than the 15th of October. [This will enable the abstracts to be printed and circulated to members before leaving their Stations to attend the Congress.]

(*b*) All papers which are to be read must be refereed by the Sectional Committee or by some person appointed by them, the decision to be final and all reports confidential. In deciding whether a paper should be read the Sectional Committees will take into consideration the question whether the paper has been previously published.

(*c*) Each paper must be accompanied by an abstract and if the paper be of great length, it should be summarised.

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[1] Added at the Bangalore Meeting, 1924.
[2] Emended at the Benares Meeting, 1925.

OFFICERS OF THE FIRST TWELVE MEETINGS OF THE INDIAN SCIENCE CONGRESS.[1]

(1914–1925.)

PATRONS.

1914. H.E. Lord Carmichael, G.C.I.E., K.C.M.G., Governor of Bengal.
1915. H.E. The Rt. Hon. Baron Pentland of Lyth, G.C.I.E., Governor of Madras.
1916. His Honour Sir James Scorgie Meston, K.C.S.I., Lieutenant-Governor of the United Provinces.
1917. H.H. The Maharajah of Mysore, G.C.S.I.
1918. H.E. Sir Michael O'Dwyer, G.C.I.E., K.C.S.I., Lieutenant-Governor of the Punjab.
1919. H.E. Sir George Lloyd, G.C.I.E., D.S.O., Governor of Bombay.
1920. The Hon'ble Sir Benjamin Robertson, K.C.S.I., K.C.M.G., C.I.E., LL.D., I.C.S., Chief Commissioner, Central Provinces.
1921. H.E. The Rt. Hon. The Earl of Ronaldshay, G.C.I.E., Governor of Bengal.
1922. H.E. Lord Willingdon, G.C.S.I., G.C.I.E., G.B.E., Governor of Madras.
1923. H.E. Sir William Marris, K.C.S.I., K.C.I.E., Governor of the United Provinces.
1924. H H. The Maharajah of Mysore, G.C.S.I., G.B.E.
1925. H.H. The Maharajah of Benares, G.C.S.I., G.C.I.E.

CONGRESS PRESIDENTS.

1914. The Hon. Justice Sir Asutosh Mukherjee, Kt., C.S.I., M.A., D.L., F.A.S.B.
1915. Major-General W. B. Bannermann, C.S.I., M.D., D.Sc., I.M.S.
1916. Colonel Sir Sydney Burrard, K.C.S.I., F.A.S.B., F.R.S., R.E.
1917. Sir Alfred Gibbs Bourne, K.C.I.E., D.Sc., F.R.S.
1918. Dr. Gilbert T. Walker, C.S.I., M.A., Sc.D., F.R.S.
1919. Lt.-Colonel Sir Leonard Rogers, Kt., C.I.E., M.D., B.S., F.R.C.P., F.R.C.S., F.A.S.B., F.R.S., I.M.S.
1920. Sir Prafulla Chandra Ray, Kt., C.I.E., Ph.D., D.Sc., F.A.S.B.
1921. Sir Rajendra Nath Mookerjee, K.C.I.E., K.C.V.O.
1922. C. S. Middlemiss, Esq., C.I.E., B.A., F.A.S.B., F.R.S.
1923. Sir M. Vishweshwarayya, K.C.I.E., M.Inst.C.E., D.Sc.
1924. Dr. N. Annandale, C.I.E., D.Sc., F.A.S.B., F.R.S.
1925. Dr. M. O. Forster, F.R.S.

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[1] As no full record of the Officers of the Congress appears inthe Proceedings of its first twelve meetings, an attempt has been made to draw up a complete list regarding these first twelve meetings now completed. This list is here added as an appendix for permanent record. A careful scrutiny has been made of the available registers, reports and other documents, but discrepancies and, in a few cases, gaps have been found. The list here presented is as correct and complete as the available material allows.

COUNCIL.

1923.

Sir Asutosh Mukherjee.
Sir Gilbert T. Walker.
Sir P. C. Ray, Kt.
Sir R. N. Mookerjee.
Sir M. Visweshwarayya.
C. S. Middlemiss, Esq.
Dr. J. L. Simonsen.
Prof. C. V. Raman.
Johan van Manen, Esq.
Dr. S. P. Agharkar.
Prof. Sampathiengar.
Dr. K. N. Bahl.
Dr. Kunjan Pillay.
Dr. Nilratan Dhar.

1924.

Sir Asutosh Mukherjee (†7th May, 1924).
Sir Gilbert T. Walker.
Sir P. C. Ray, Kt.
Sir R. N. Mookerjee.
Sir M. Visweshwarayya.
Dr. N. Annandale (†10th April, 1924)
Dr. J. L. Simonsen.
Prof. C. V. Raman.
Dr. S. P. Agharkar.
Dr. Baini Prashad.
Johan van Manen, Esq.
Prof. Sampathiengar.
Dr. K. N. Bahl.
Dr. Kunjan Pillay.
Dr. Nilratan Dhar.
Dr. S. N. Mukerjee.

1925.

Sir P. C. Ray, Kt.
Sir R. N. Mookerjee.
Sir M. Visweshwarayya.
Dr. M. O. Forster.
Dr. Baini Prashad.
Dr. J. L. Simonsen.
Dr. S. P. Agharkar.
Dr. S. L. Hora.
Dr. E. R. Watson.
Dr. D. M. Bose.
Johan van Manen, Esq.
Prof. H. C. Das-Gupta.
Prof. G. Mathai.
Prof. S. L. Ajrekar.
Mr. A. Howard.
Dr. B. Sahni.

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1916.

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Prof. P. S. MacMahon.
R. D. Mehta, Esq. (Treasurer, A.S.B.).
Dr. F. H. Gravely (Gen. Sec., A.S.B.).

1917.

Dr. Gilbert T. Walker.
Sir Alfred Bourne.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon. (In England.)
R. D. Mehta, Esq. (Treasurer, A.S.B.).
Dr. F. H. Gravely (Gen. Sec., A.S.B.).

1918.

Sir Leonard Rogers.
Dr. Gilbert T. Walker.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon. (In England.)
R. D. Mehta, Esq. (Treasurer, A.S.B.).
Dr. F. H. Gravely (Gen. Sec., A.S.B., up to end of February).
Dr. W. A. K. Christie (Gen. Sec., A.S.B., from March).

1919.

Sir P. C. Ray, Kt.
Sir Leonard Rogers.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon.
R. D. Mehta, Esq. (Treasurer, A.S.B.).
Dr. W. A. K. Christie (Gen. Sec., A.S.B.).

1920.

Sir R. N. Mookerjee.
Sir P. C. Ray, Kt.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon.
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Dr. W. A. K. Christie (Gen. Sec., A.S.B., up to May).
A. H. Harley, Esq. (Gen. Sec., A.S.B., from May).

1921.

Sir Thomas Holland (up to ?).
C. S. Middlemiss, Esq. (from ?).
Sir R. N. Mookerjee.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon.
Oswald Martin, Esq. (Treasurer, A.S.B., up to November).
A. H. Harley, Esq. (Treasurer, A.S.B., from November).
Dr. W. A. K. Christie (Gen. Sec., A.S.B).

1922.

Lt.-Col. A. T. Gage (up to ?).
Sir M. Visweshwarayya (from ?).
C. S. Middlemiss, Esq.
Dr. J. L. Simonsen.
Dr. C. V. Raman.
W. R. C. Brierley, Esq. (Treasurer, A.S.B.).
Dr. W. A. K. Christie (Gen. Sec., A.S.B., up to March).
Dr. S. W. Kemp („ „ up to July).
Dr. E. P. Harrison („ „ up to 31st August).
A. H. Harley, Esq. („ „ up to end of September).
Dr. S. W. Kemp („ „ from October).

1923.

Sir Asutosh Mukherjee. (Resigned in November.)
Dr. N. Annandale (from November).
Sir M. Visweshwarayya.
Dr. J. L. Simonsen.
Dr. C. V. Raman (Gen. Sec., I.Sc.C., and Treasurer, A.S.B.).
Dr. S. W. Kemp (Gen. Sec., A.S.B., up to February).
Johan van Manen, Esq. (Gen. Sec., A.S.B., from February).

1924.

Dr. M. O. Forster.
Dr. N. Annandale (†10th April).
Dr. J. L. Simonsen. (In England from April.)
Dr. C. V. Raman (up to May).
Dr. S. P. Agharkar (from May).
Dr. N. R. Dhar.
Dr. Baini Prashad (Treasurer, A.S.B.).
Johan van Manen, Esq. (Gen. Sec., A.S.B.).

1925.

A. Howard, Esq.
Dr. M. O. Forster.
Dr. J. L. Simonsen.
Dr. S. P. Agharkar.
Dr. B. Sahni.
Dr. Baini Prashad (Treasurer, A.S.B., up to 3rd August).
Dr. S. L. Hora (,, ,, from 3rd August).
Johan van Manen, Esq. (Gen. Sec., A.S.B.).

(*N.B.*—The General Secretary and Treasurer of the Asiatic Society of Bengal were *ex-officio* members of the Executive Committee of the Congress.)

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1916. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1917. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1918. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1919. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1920. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1921. Prof. J. L. Simonsen.
Prof. P. S. MacMahon (up to April).
Dr. C. V. Raman (from April).
1922. Prof. J. L. Simonsen.
Prof. C. V. Raman.
1923. Prof. J. L. Simonsen.
Prof. C. V. Raman.
1924. Prof. J. L. Simonsen.
Prof. C. V. Raman (up to May).
Prof. S. P. Agharkar (from May).
1925. Prof. J. L. Simonsen.
Prof. S. P. Agharkar.

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1915. R. D. Mehta, Esq.
1916. R. D. Mehta, Esq.
1917. R. D. Mehta, Esq.
1918. R. D. Mehta, Esq.
1919. R. D. Mehta, Esq.
1920. Oswald Martin, Esq.
1921. Oswald Martin, Esq. (up to 24th November).
A. H. Harley, Esq. (from 24th November).
1922. W. E. C. Brierley, Esq.
1923. Dr. C. V. Raman.
1924. Dr. C. V. Raman (up to May).
Dr. Baini Prashad (from May).
1925. Dr. Baini Prashad (up to 3rd August).
Dr. S. L. Hora (from 3rd August).

(*N.B.*—The Treasurer of the Asiatic Society of Bengal was *ex-officio* Treasurer of the Congress.)

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1917. J. MacKenna, Esq., C.I.E., M.A.
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1923. Dr. N. Kunjan Pillay, M.A., B.Sc., Ph.D.
1924. B C. Burt, Esq., M.B.E., B.Sc.
1925. R. S. Finlow, Esq., B.Sc., F.I.C.

Physics and Mathematics.[1]

1914. V. H. Jackson, Esq., M.A.
1915. Dr. C. V. Raman, M.A.
1916. Dr. G. C. Simpson, C.B.E., F.A.S.B., F.R.S.
1917. The Rev. Dr. D. Mackichan, D.D., LL.D.
1918. Dr. Wali Mohammad, M.A.
1919. Dr. D. N. Mallik, B.A., F.R.S.E.
1920. Dr. N. A. F. Moos, F.R.S.E.
1921. J. H. Field, Esq., M.A.
1922. T. P. Bhaskara Shastri, Esq., M.A., F.R.A.S.
1923. Dr. S. K. Banerjee, D.Sc.
1924. Prof. C. V. Raman, M.A., D.Sc., F.R.S.
1925. Prof. E. P. Metcalfe, B.Sc., F.Inst.P.

Chemistry.

1914. P. S. MacMahon, Esq., M.Sc., B.Sc.
1915. Sir P. C. Ray, Kt., C.I.E., Ph.D., F.A.S.B.
1916. Dr. J. J. Sudborough, F.I.C.
1917. Dr. J. L. Simonsen, F.I.C., F.A.S.B.

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[1] A note states that, in 1917, there was a separate section of Mathematics, with Dr. Zia-ud-din Ahmed, C.I.E., as President. The Proceedings for that year contain no reference to this.

1918. Dr. G. J. Fowler, F.I.C.
1919. F. L. Usher, Esq., B.Sc.
1920. B. K. Singh, Esq., M.A., F.I.C.
1921. Dr. H. E. Watson, A.I.C.
1922. Dr. N. R. Dhar, F.I.C.
1923. Dr. A. N. Meldrum, D.Sc.
1924. Dr. E. R. Watson, M.A., D.Sc.
1925. Prof. J. C. Ghosh, D.Sc.

Zoology.

1914. Dr. J. R. Henderson, C.I.E.
1915. Dr. N. Annandale, F.A.S.B.
1916. Dr. W. N. F. Woodland.
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1924. Dr. K. N. Bahl, D.Sc., Ph.D.
1925. Dr. Baini Prashad, D.Sc.

Botany.

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1925. Prof. R. S. Inamdar, B.Ag., B.A.

Geology.

1914. Sir H. H. Hayden, Kt., C.S.I., C.I.E., D.Sc. F.A.S.B., F.R.S.
1915. Dr. W. F. Smeeth, M.A., A.R.S.M., F.G.S.
1917. C. S. Middlemiss, Esq., C.I.E., M.A., F.R.S.
1918. E. S. Pinfold, Esq., B.A., F.G.S.
1919. Dr. L. L. Fermor, O.B.E., A.R.S.M., F.A.S.B.
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1923. Dr. E. H. Pascoe, M.A., D.Sc., F.G.S.
1924. Dr. W. F. Smeeth, M.A., A.R.S.M., F.G.S.
1925. Dr. G. E. Pilgrim, D.Sc., F.G.S.

(There was no Section of Geology in 1916.)

Medical Research.

1919. Lt.-Colonel W. Glen Liston, C.I.E., M.D., D.P.H., I.M.S.
1920. Lt.-Colonel W. F. Harvey, C.I.E., M.A., M.D., D.P.H., I.M.S.
1921. Lt.-Colonel J. W. D. Megaw, B.A., M.D., I.M.S.
1922. Major Cunningham, B.A., M.D., I.M.S.
1923. Major H. W. Acton, I.M.S.
1924. Lieut.-Col. S. R. Christophers, C.I.E., O.B.E., M.B., F.R.S., I.M.S.
1925. Lieut.-Col. F. P. Mackie, O.B.E., M.D., M.Sc., F.R.C.S., F.R.C.P., I.M.S.

Anthropology.

1914. L. K. Anantakrishna Ayyar, Esq., M.A.
1915. H. V. Nanjundayya, Esq., C.I.E., M.A.
1921. Rai Bahadur Sarat Chandra Roy, M.A., B.L., M.L.C.
1922. Rai Bahadur Hiralal, B.A., M.R.A.S.
1923. Shams-ul-Ulama Dr. Jivanji Jamshedji Modi, B.A., Ph.D. C.I.E.
1924. Rao Bahadur L. K. Ananthakrishna Ayyar, B.A., L.T., F.R.A.I.
1925. P. C. Mahalanobis, Esq., M.A., B.Sc.

(There were no separate meetings of the Section of Anthropology in intermediate years.)

Psychology.

1925. Dr. N. N. Sen-Gupta, M.A., Ph.D.

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1923. Hon. Mr. C. Y. Chintamani.
1924. Sir B. N. Seal, Kt.
1925. Pandit Madan Mohan Malavya.

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Dr. Hassan Suhrawardy.
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Khan Sahib Md. Azizullah Sahib Bahadur, B.A., M.B., C.M.
1923. Prof. P. S. MacMahon.
Dr. Wali Muhammad.
1924. Prof. F. L. Usher.
S. A. Ramaswami Iyer, Esq.
1925. Prof. L. D. Coueslant, B.Sc., A.M.I.M.E.
Prof. K. K. Mathur, B.Sc., A.R.C.S.

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